FLOOD INSURANCE STUDY

MARIN COUNTY, CALIFORNIA
UNINCORPORATED AREAS

REVISED: MAY 5,1997

Federal Emergency Management Agency

COMMUNITY NUMBER - 060173

NOTICE TO FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for flood plain management and flood insurance purposes. This Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

This publication incorporates revisions to the original Flood Insurance Study. These revisions are presented in Section 9.0.

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FLOOD INSURANCE STUDY

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study revises and updates a previous Flood Insurance Study/Flood Insurance Rate Map for the unincorporated areas of Marin County, California. This information will be used by Marin County to update existing flood plain regulations as part of the regular phase of the National Flood Insurance Program (NFIP). The information will also be used by local and regional planners to further promote sound land use and flood plain development.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for the original study were performed by the U.S. Army Corps of Engineers (COE), for the Federal Emergency Management Agency (FEMA), under Inter-Agency Agreement No. IAA-H-10-77, Project Order No. 5, Amendment 5. This study was completed in November 1979.

The coastal analyses for the revised study were conducted by Ott Water Engineers, Inc., for FEMA, under Contract No. EMW-83-C-1175. This work was completed in August 1984.

1.3 Coordination

Representatives of the COE and FEMA met with Marin County officials on December 21, 1978, to discuss the study and collect local input. Numerous informal meetings were held between the study contractor and county personnel to discuss the study.

The results of the original study were reviewed at the final community coordination meeting held on March 25, 1981, and attended by representatives of FEMA, the study contractor, and the county. All problems raised at that meeting were resolved.

For this revised study, additional coastal areas requiring detailed study were identified at the initial coordination meetings attended by representatives of the study contractor and Marin County on May 24, 25, and 27, 1983.

Engineering firms, residents, and business owners were interviewed at each of the detailed-study areas. The status of shore protection measures and the extent of recent coastal damage were noted.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the unincorporated areas of Marin County, California. The area of study is shown on the Vicinity Map (Figure 1).

Federal lands that were not included in this study are Hamilton Air Force Base, Mill Valley Air Force Station, San Quentin State Penitentiary, Fort Baker Military Reservation, Fort Barry Military Reservation, Fort Cronkhite Military Reservation, Two Rock Ranch Station Military Reservation (U.S. Coast Guard Training Center), Hill 640 Military Reservation, Tiburon Naval Net Depot, Bolinas Military Reservation, and Frank Valley Military Reservation.

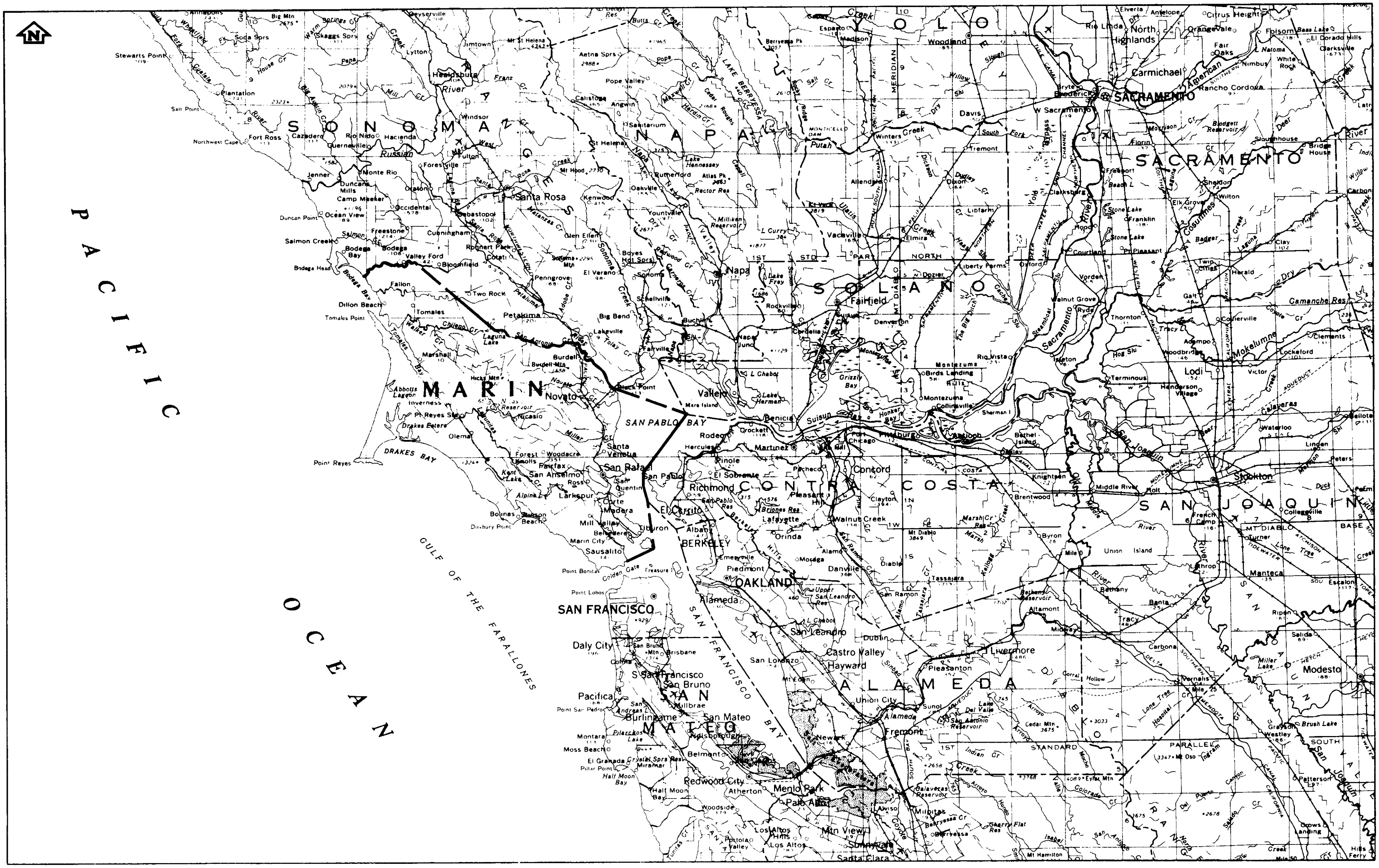
Incorporated communities not included in this study are the City of Belvedere, Town of Fairfax, Town of Corte Madera, City of Larkspur, City of Mill Valley, City of Novato, Town of Ross, City of San Anselmo, City of San Rafael, City of Sausalito, and City of Tiburon.

Areas along the following streams were studied by detailed methods in the original study: Coyote Creek, Tennessee Creek, Crest Marin Creek, Reed Creek, Sutton-Manor Creek, Eskoot Creek, Novato Creek (Novato corporate limits to Stafford Dam), Arroyo San Jose, Miller Creek, Lagunitas Creek, and Olema Creek. Coastal or tidal areas were studied by detailed methods in the original study along Bolinas Lagoon at Eskoot Creek, San Francisco Bay, and San Pablo Bay.

Coastal flooding from the Pacific Ocean in the vicinity of Bolinas Bay has been studied in detail for this revision. In addition, this revision includes detailed-study reaches from Bolinas Lagoon, which supersedes previous delineations for Bolinas Lagoon at Eskoot Creek.

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through 1989.

Areas were studied by approximate methods along Bel Aire area tributaries to Richardson Bay; Pine Gulch Tributary to Bolinas Bay;



APPROXIMATE SCALE

16 0 16 32 48 MILES

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

VICINITY MAP

FIGURE 1

San Antonio Creek, upstream from U.S. Highway 101; Corte Madera Creek, from downstream of Ross to the mouth; and the coast of San Francisco Bay from Corte Madera to San Quentin.

2.2 Community Description

Marin County encompasses the entire peninsula that forms the northwestern boundary of San Francisco and San Pablo Bays, extending north to the Petaluma River estuary on the east and to Bodega Bay on the west. The county covers an area of approximately 521 square miles in central California along the west coast. The county includes 11 incorporated cities and numerous unincorporated communities. The 1980 population of Marin County was 222,568, with 63,179 people living in unincorporated areas (Reference 1). There is a combination of State, county, city, and private road networks consisting of over 650 miles. The San Andreas geologic fault runs approximately north and south in the western part of the county. Approximately two-thirds of the county border is adjacent to water. Marin County is bounded by Sonoma County to the north, Contra Costa County to the east, and San Francisco County to the south.

Incorporated cities in Marin County are mostly along the eastern edge of the county. Most of the flatland along the creeks studied has been developed to moderate-density suburban areas with very high land values. Most of the western areas of the county are incorporated into the Golden Gate National Recreation Area or state parks. Little new development can be accommodated in many of the areas studied. Drainage basin areas for the studied streams are small and this, combined with the steep terrain, results in rapidly developing streamflows of short duration.

Topographically, Marin County can be described as hilly to mountainous. Typically, the county consists of numerous relatively flat, narrow valleys that lie between steep to rolling ridges varying in height from a few hundred feet to more than 1,000 feet. The mountainous character of the county significantly affects precipitation distribution. The climate of Marin County is characterized by warm, dry summers and mild, wet winters. The hottest month is July, with a mean daily maximum temperature of 83°F. The coldest month is January, with a mean daily minimum temperature of 38°F. Snowfall is rare and has no effect on flood runoff. Precipitation is concentrated during October through April, when 95 percent of the seasonal precipitation normally occurs. Normal annual precipitation ranges from 30 inches in the north to approximately 60 inches along the higher ridges of the county.

Soils are generally shallow, except in the valley areas, and vegetation ranges from mostly nonnative plants in the suburban areas to large second- and third-growth timber and annual grasses on the steeper slopes.

The unincorporated communities of Bolinas and Stinson Beach are approximately 15 miles northwest of San Francisco along Bolinas Bay. Bolinas is located on the western headland of the Bolinas Lagoon, while Stinson Beach is located on the sand spit that separates the lagoon from the ocean. The lagoon inlet separates Bolinas from Stinson Beach. Both communities are residential resort areas, and virtually all beachfront properties have been developed. No new developments are known at this time.

Rainfall over much of the basins studied is heavy, and rainy season flooding is frequent. Since 1950, major floods have occurred in 1952, 1955, 1958, 1967, 1969, 1970, 1973, and 1975, with the storm of December 1955 generally considered to be the largest of this period. However, while most streams studied have short or nonexistent gage records, it is unlikely that any storm in this period produced peak stream discharges greater than a 20- to 25-year event on the basins studied.

2.3 Principal Flood Problems

The principal watercourses in Marin County are Coyote Creek, Reed Creek, Sutton-Manor Creek, Eskoot Creek, Novato Creek, Miller Creek, Lagunitas Creek, Olema Creek, Rush Creek, and their tributaries.

Six nonnatural reservoirs in the county are adjacent to the San Andreas fault. An earthquake could rupture the dams and cause flash flooding in populated areas. These dams offer no flood protection because they were built primarily for water supply.

The floods in Marin County are normally of short duration, lasting only 3 or 4 days. Floods may develop with 24 hours after the beginning of a flood-producing storm and will normally recede within 1 day after the end of the storm. Tributaries rise rapidly, so that flooding begins a few hours after the occurrence of heavy rainfall. Sheetflow flooding is caused by inadequate channel capacity and poor drainage in areas close to streams.

Flood peaks for the streams in Marin County generally occur between December and March, although records show that they have occurred as early as November and as late as April.

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The flooding conditions on the minor streams of Marin County are similar to those found in the major basins.

Coastal flooding in Marin County is typically associated with the simultaneous occurrence of very high tides, large waves, and storm swells during the winter. As a result, oceanfront development has not been compatible with the natural instability of the shoreline and the intense winter weather conditions.

Tsunami (sea waves generated from oceanic earthquakes, submarine landslides, and volcanic eruptions) create some of the most destructive natural water waves. As tsunami waves approach shallow coastal waters, wave refraction, shoaling, and bay resonance amplify the wave heights.

Storm centers from the southwest produce the type of storm pattern most commonly responsible for the majority of the serious coastal flooding. The strong winds and high tides that create storm surges are also accompanied by heavy rains. In some instances, high tides back up riverflows, which causes flooding at the river mouths.

The most severe storms to hit the Marin County coastline occurred in 1978 and 1983 when high-water levels were accompanied by very large storm waves.

In January 1978, a series of storms emanated from a more southerly direction than those that normally occur; consequently, some of the better-protected beaches were damaged.

Jetties and breakwater barriers were overtopped and in some cases undermined. Direct wave damage occurred to many beachfront homes, especially in the more populated beachfront areas in Stinson Beach. Accelerated erosion coupled with saturated ground conditions and rain weakened the foundations of homes in Bolinas located on the top of beach bluffs. Seawalls and temporary barriers failed to protect beachfront properties from the ravages of the 1978 storms.

The winter of 1983 brought an extremely unusual series of high tides, storm surges, and storm waves along the California coast (Reference 2).

2.4 Flood Protection Measures

No projects are being maintained or operated by the COE in Marin County. From time to time, under the authority of Public Law 99, 84th Congress, or Public Law 875, 81st Congress, emergency channel restoration and levee repairs have been carried out.

Flood-control projects (concrete channels) have been built in Marin County by the COE; one is on Coyote Creek, and one is on Corte Madera Creek. The projects have no effect on the 100- and 500-year floods and do not affect the flood plain or discharges.

Local interests have constructed approximately 75 miles of levees in the county. These levees are concentrated in the low-lying areas around Richardson Bay and the Cities of San Rafael and Novato.

A Marin County ordinance controlling tidal areas states that the first floor of a structure must be at an elevation of at least 7 feet.

Over one-half of the Stinson Beach peninsula has been riprapped for shore protection, although the southern portion of the beach is unprotected. It is expected that if this shore protection is maintained, it will withstand the 100-year flood (Reference 2).

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

Flood hazards along the Pacific coast may be generated by swell waves from offshore storms, by wind waves from landfalling storms, or by tsunami. The degree of hazard depends on the water-surface elevation of the astronomical tide at the time of wave or tsunami occurrence. To evaluate the flood hazards from the Pacific Ocean, detailed engineering studies separately defined the runup magnitude and frequency of astronomical tide plus swell waves arriving from both the northwest and southwest directions, the runup magnitude and frequency of tide plus wind waves arriving from both the northwest and southwest directions, and the magnitude and frequency of tide plus tsunami. These magnitude and frequency relations were statistically combined to provide a comprehensive evaluation of the coastal flood hazard from the Pacific Ocean.

In northern California bays and lagoons protected from open-ocean waves, the flood hazards are generated by storm and/or tsunami, and the degree of hazard depends on the water-surface elevations of the astronomical tide at the time of storm or tsunami occurrence. To evaluate the flood hazards from Bolinas Lagoon, detailed engineering studies separately defined the magnitude and frequency of the storm-plus-tide impacts and the magnitude and frequency of tsunami plus tides, and then statistically combined the storm and tsunami components to provide a comprehensive evaluation of the coastal flood hazard.

Details of the methodology are provided in Reference 2; a summary description is provided in Section 3.3.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the community.

There are 6 U.S. Geological Survey stream-gaging stations and roughly 10 partial-record stations on the streams in Marin County (Reference 3). The gaging stations are on San Antonio, Novato, Corte Madera, Arroyo Corte Madera del Presidio, Lagunitas, and Walker Creeks. The gage on Novato Creek has the longest period of record and dates from October 1946. Values of the 10-, 50-, 100-, and 500-year peak discharges were obtained from a log-Pearson Type III distribution of annual peak flow data.

The approach taken for development of discharges on streams without gages was to determine the 100-year-event peak discharge for as many streams as possible in Marin County, then to use the technique of multiple regression analysis in determining the most reliable estimate of the 100-year peak discharges for any given area in Marin County. The streams without gages were Arroyo San Jose and Coyote, Tennessee, Crest Marin, Reed, Sutton-Manor, Eskoot, Miller, and Olema Creeks.

Peak discharge-drainage area relationships for all streams studied in detail are shown in Table 1.

Analyses were also carried out to establish the peak elevation-frequency relationships for each tidal flooding source studied in detail.

Tidal elevations for San Pablo and Richardson Bays were taken from data at the U.S. Coast and Geodetic Survey gage at the Presidio on San Francisco Bay, with 73 years of records (Reference 4). Elevations for these areas were determined based on an elevation-frequency curve of the annual maximum flood levels recorded at the Presidio.

Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Coyote Creek					
At State Highway 1 Bridge	3.48	1,240	1,860	2,110	2,630
Downstream of Confluence With Tennessee Creek	3.37	1,200	1,800	2,040	2,550
Upstream of Confluence With Tennessee Creek	1.56	680	1,000	1,120	1,390
At Ash Street	1.32	540	800	910	1,130
Tennessee Creek					
Upstream of Confluence With Coyote Creek	1.81	550	840	960	1,220
Upstream of Confluence With Crest Marin Creek	1.51	440	680	780	980
Crest Marin Creek					
Upstream of Confluence With Tennessee Creek	0.30	110	160	180	240
Reed Creek					
At Evergreen Avenue	0.84	250	380	430	540
Sutton-Manor Creek					
At Mouth	1.00	300	535	625	765
Eskoot Creek					
At Bolinas Lagoon	1.59	666	970	1,090	1,350
At State Highway 1	1.32	540	810	910	1,130
Novato Creek					
At Upstream Corporate Limits of Novato	13.80	1,300	2,100	2,500	3,800
At Stafford Dam	10.30	900	1,500	1,900	2,800

Table 1. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-Year	50-Year	100-Year	500-Year
Arroyo San Jose					
At U.S. Highway 101	5.4	1,200	1,900	2,300	2,900
Miller Creek (Leveed Channel)					
At Mouth	9.35	1,190	1,190	1,190	1,190
Miller Creek (Upstream Channel)					
At the Southern Pacific Railroad	9.35	1,600	2,540	2,870	3,395
Lagunitas Creek					
At Point Reyes Station Bridge	107.3	14,700	25,000	28,050	34,840
Olema Creek					
At Bear Valley Road Bridge	14.6	3,590	5,150	5,720	6,810
Miller Creek - Left Overbank Channel					
Approximately 830 feet upstream of the Southern Pacific Railroad	N/A	--[1]	--[1]	1,665	--[1]
Approximately 1,900 feet upstream of the Southern Pacific Railroad	N/A	--[1]	--[1]	1,344	--[1]
Approximately 2,550 feet upstream of the Southern Pacific Railroad	N/A	--[1]	--[1]	954	--[1]
Miller Creek - Right Overbank Channel					
Approximately 1,160 feet upstream of the Southern Pacific Railroad	N/A	--[1]	--[1]	2,010	--[1]
Approximately 1,830 feet upstream of the Southern Pacific Railroad	N/A	--[1]	--[1]	545	--[1]
Approximately 2,880 feet upstream of the Southern Pacific Railroad	N/A	--[1]	--[1]	185	--[1]

[1]Data not determined

Elevations for floods of the selected recurrence intervals on San Pablo Bay, Richardson Bay, Bolinas Lagoon, and the Pacific Ocean are shown in Table 2. Flooding from Bolinas Lagoon and the Pacific Ocean is discussed in Section 3.3.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

The hydraulic information developed during a 1972 Flood Insurance Study for Marin County (Reference 5) was reevaluated and expanded for this study by using more up-to-date topographic information. Aerial photographs were utilized to determine changes in topography due to urbanization.

Water-surface elevations of floods of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 6).

Cross-sectional data for streams studied in detail were obtained from existing topographic maps, channel improvement plans, bridge drawings, or field surveys. Cross sections were located at close intervals above and below bridges and culverts to compute the significant backwater effects of these structures.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-sectional locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

The starting water-surface elevations for Reed and Sutton-Manor Creeks were taken from the Flood Insurance Study for the City of Mill Valley (Reference 7). The starting water-surface elevations for Novato Creek and Arroyo San Jose were taken from the Flood Insurance Study for the City of Novato (Reference 8).

The Eskoot and Lagunitas Creek starting water-surface elevations were set by tidal elevations. The Olema Creek starting water-surface elevation was based on coincident flows at the confluence with Lagunitas Creek. The Crest Marin and Tennessee Creek starting water-surface elevations were based on coincident flows at their confluences with Coyote Creek.

Roughness coefficients (Manning's "n") for streams studied in detail are shown in Table 3.

Table 2. Summary of Stillwater Elevations

Flooding Source and Location	Elevation (Feet) 10-Year	50-Year	100-Year	500-Year
San Pablo Bay				
Petaluma River Entrance	5.1	--[1]	5.5	5.7
San Francisco Bay				
Point San Quentin and Vicinity	5.4	--[1]	6.0	6.3
Sausalito and Vicinity	5.3	--[1]	5.9	6.2
Bolinas Lagoon				
Eskoot Creek Entrance	5.0	5.4	5.5	5.8
Pacific Ocean				
Bolinas/Stinson Beach	5.0	5.4	5.5	5.8

[1] Data Not Available

Table 3. Summary of Roughness Coefficients (Manning's "n")

Flooding Source	Range of Roughness Values Main Channel	Range of Roughness Values Overbank Area	Bridge and Culvert Structures
Coyote Creek			
Downstream of Earthen Channel	0.040	0.080	0.025 Flamingo Bridge
Upstream of Concrete Channel	0.014	N/A	N/A
Tennessee Creek			
Mouth to Upstream Entrance of Concourse Bridge	0.040	0.070	0.014 Marin Avenue
Entrance of Concourse Bridge to Upstream End	0.050	0.070	Enterprise Concourse Bridges
Crest Marin Creek			
Mouth to Upstream of Poplar Street	0.060	0.100	
Maple Street to Poplar Street	0.060	0.100	
Reed Creek	0.060	0.100	0.014
Miller Creek			
Stations 400 to 33,373	0.040	0.040	0.040
Lagunitas Creek			
Station 0	0.035	0.035	0.035
7,838	0.035	0.035	0.060
9,958	0.035	0.035	0.050
11,330	0.035	0.035	0.070
12,809	0.045	0.060	0.060
14,885	0.045	0.060	0.070
15,876	0.060	0.070	0.070
Olema Creek			
Station 0	0.035	0.035	0.050
570	0.070	0.070	0.050
2,458	0.050	0.050	0.050
2,730	0.050	0.050	0.080
10,240	0.080	0.080	0.050

For streams studied by approximate methods, flooded areas were determined using Manning's equation and normal-depth techniques. The approximate flooding areas of the bays were determined using the highest estimated tide taken from local tidal bench marks.

Shallow flooding on detailed-study streams was hand calculated by determining the 100-year discharge, determining the channel capacity, and finding the amount of overflow. Using Manning's equation, a relationship between depth and hydraulic radius was computed, and the width and depth of the flow were determined.

For the large ponding areas on Arroyo San Jose, 1,000 feet downstream of Bel Marin Keys, the water-surface elevation was determined using a flood-routing analysis.

Tidal elevations for the 10-, 50-, 100-, and 500-year events were taken from U.S. Geological Survey gage records from the Presidio of San Francisco (Reference 3), in conjunction with mean higher high-water and highest estimated tide values for specific locations. The frequencies for mean higher high-water and highest estimated tide for local tide gages are assumed to be equal to those at the Presidio gage.

The effects of tsunami-induced flooding were considered based on previous studies (References 9 and 10) and found to be insignificant in the northern end of San Francisco Bay.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps.

3.3 Coastal Hazard Analyses

For the Pacific Ocean, swell-wave and wind-wave frequency and magnitude components were determined by a two-step process. The first step defined a stillwater elevation that included the effects of astronomical tide, storm surge, and wave setup. The second step determined wave runup above the stillwater elevation onto the beach.

Storm surge from the Pacific Ocean was defined by a two-dimensional, finite-element computer model (Reference 11). Applicability of the model had been tested by using long-term climatic records for San Francisco (Reference 12) to synthesize a long-term record of storm-surge hydrographs for San Francisco Bay. The close match of the synthesized data to available long-term tidal records confirmed the usability of the model for California coastal conditions. For the Pacific Ocean, the model synthesized a record from 1955 to 1983 of storm surge, windspeed, wind direction, and barometric pressure data, as determined from Three-Hourly North American Surface Weather Maps (Reference 13). The frequency and magnitude of storm surges were defined from the synthesized storm-surge record.

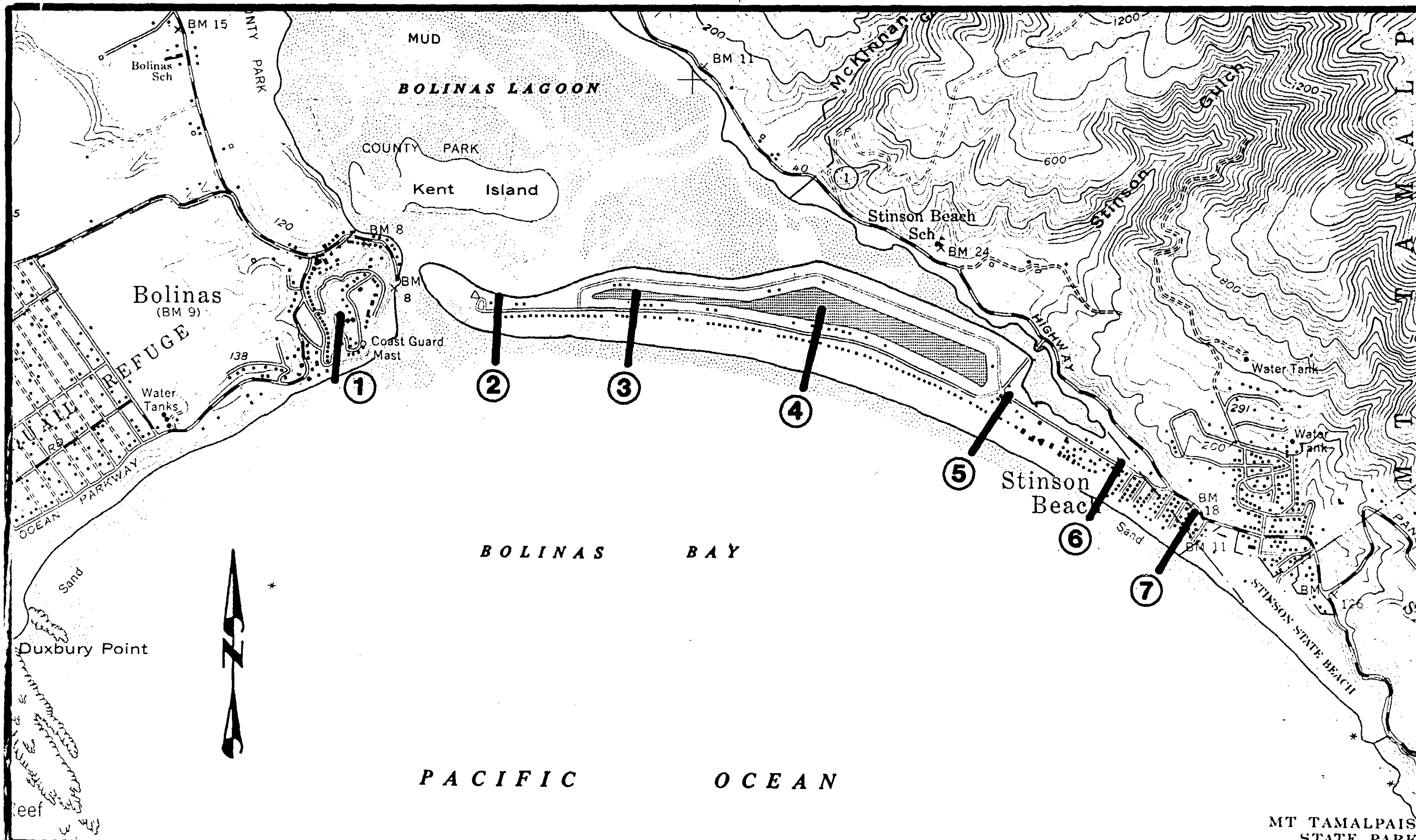
The effect of storm surge was combined with astronomical tide and wave setup to define the stillwater elevation needed to evaluate the wind-wave runup. Characteristics of astronomical tide in Marin County could be reliably defined from previous studies (Reference 14) and were convoluted with storm surge (Reference 15). The magnitude of wind-wave setup was calculated by an iterative process coupled with the wave runup calculations.

Runup of wind waves was evaluated by first determining the deepwater wave conditions from both the southwest and northwest using the 1955-to-1983 climatic data and methods described in Reference 15. A wave-tracking model (Reference 16) then transformed the deepwater waves as they traveled toward the shoreline on the basis of bathymetry and beach profiles. Beach transects along the coast provided a generalized representation of the beach profiles that control the magnitude of wave runup. In coastal-study areas, beach transects were oriented perpendicular to the shoreline and were strategically located along the shore to represent reaches with similar characteristics. (See Figure 2.) Data were primarily obtained from offshore bathymetry maps supplemented with 1978 COE survey data (Reference 17). Table 4 provides a listing of the transect locations, and Figure 3 presents a sample transect. The wave runup along sloping sandy beaches was computed by Hunt's method (Reference 18); at obstructions, it was computed by Stoa's method (Reference 19).

The elevation-probability distribution for swell waves followed a similar development. Stillwater was defined only from wave setup convoluted with astronomical tide. The frequency of offshore wave height and wave period from the northwest and southwest was determined from available data (Reference 20) and routed shoreward with the wave-tracking model. The runup elevation at each beach transect was calculated using Hunt's and Stoa's methods.

Tsunami plus astronomical tide elevations having 100- and 500-year recurrence intervals have been published (References 21, 22, and 23), and for this analysis, the complete magnitude-frequency relationship was defined from supporting data for those earlier studies.

The combined probability of wind waves from the northwest and southwest, of swell waves from the northwest and southwest, and of tsunami was defined on the assumption that the events are independent.



FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

APPROXIMATE SCALE IN FEET

1000 0 1000 3000 5000 7000

TRANSECT LOCATION MAP
STINSON BEACH/BOLINAS

FIGURE 2

Table 4. Transect Locations

Study Area	Transect Number	Location
Bolinas/Stinson Beach	1	In Bolinas, from coastline and east along Terrace Street.
	2	In Stinson Beach, from the coastline, northeast to Seadrift Road, and stopping approximately 400 feet from the road's northwest end.
	3	In Stinson Beach, from the ocean edge, northeast along residence 284 Seadrift Road to the southwest shore of the lagoon.
	4	From the ocean edge in Stinson Beach, northeast along 194 Seadrift Road to the edge of the lagoon.
	5	From the ocean edge in Stinson Beach, northeast along Walla Vista to Calle del Arroyo.
	6	From the water's edge in Stinson Beach along Calle del Occidente to its terminus and beyond the five houses.
	7	From the water's edge in Stinson Beach along Calles del Pradero to its intersection with State Highway 1.

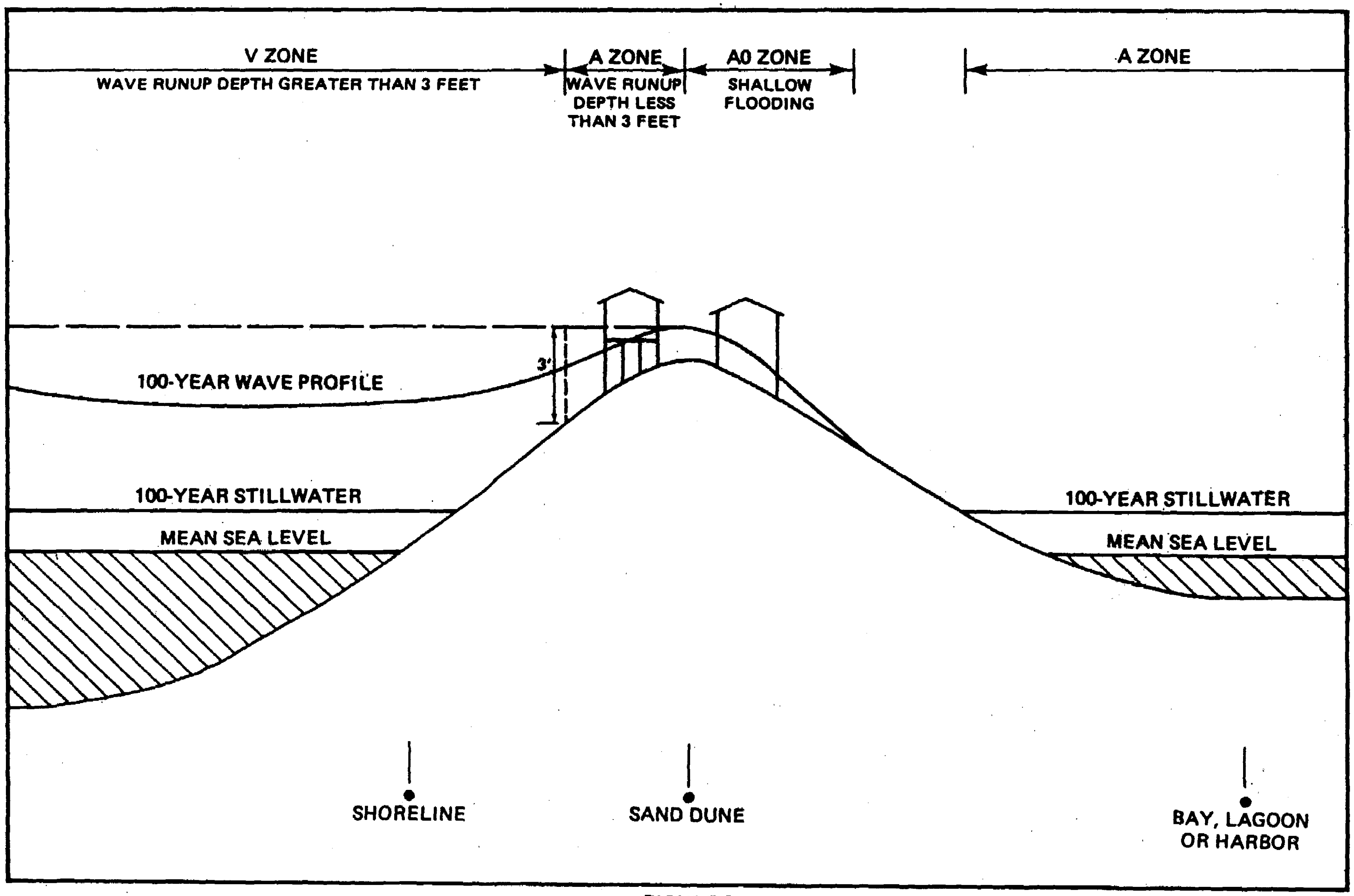


FIGURE 3
TYPICAL TRANSECT SCHEMATIC

For Bolinas Lagoon, storm-generated components of the coastal flood hazard were evaluated by a three-step analysis. The first step determined the magnitude and frequency of storm surge, or the super-elevation of the water level above the astronomical tide that is caused by low barometric pressure and by wind stresses. The second step convoluted storm-surge probabilities with astronomical tide characteristics to define the stillwater elevation and frequency relation. Finally, wave impacts were defined and added to still-water elevations.

Storm surge from Bolinas Lagoon was defined using the same methods employed in the study of the Pacific coast (References 11, 12, and 13).

Because of inlet constrictions, Bolinas Lagoon was assumed to be sheltered from the influence of offshore storm-generated waves, but the magnitudes of locally generated wind waves were investigated using methods from the Shore Protection Manual (Reference 15). Based on wind magnitude and frequency data, measured fetch lengths, and beach profiles, the wave heights were found to be generally less than 3 feet and to provide only limited runup above the still-water elevation. Hence, wave action was considered insignificant to the flood hazard from Bolinas Lagoon (Reference 2).

The results of these coastal analyses are presented in Table 2.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study produces maps designed to assist communities in developing flood plain management measures.

4.1 Flood Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for flood plain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the 100- and 500-year flood plain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:24,000, with a contour interval of 40 feet (Reference 24).

Detailed flood plain boundaries along the Pacific Ocean and Bolinas Lagoon were delineated using topographic maps at a scale of 1:4,800, with a contour interval of 4 feet, developed from aerial photographs (Reference 25).

Approximate 100-year flood plain boundaries in some portions of the study area were taken directly from the Flood Hazard Boundary Map for Marin County (Reference 26).

Approximate 100-year flood plain boundaries in some portions of the study area were delineated using the previously cited topographic maps (Reference 24).

Some sheetflow boundaries were taken from a 1972 Flood Insurance Study of Marin County (Reference 5).

For the streams studied by approximate methods, only the 100-year flood plain boundary is shown.

The 100- and 500-year flood plain boundaries are shown on the Flood Boundary and Floodway Map (Exhibit 2). In cases where the 100- and 500-year flood plain boundaries are close together, only the 100-year flood plain boundary has been shown. Small areas within the flood plain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

4.2 Floodways

Encroachment on flood plains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood plain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plain. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 5).

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Coyote Creek								
A	2,310[1]	93	600	3.4	6.2	6.2	7.2	1.0
B	2,610[1]	85	570	3.6	6.6	6.6	7.5	0.9
C	2,910[1]	200	830	2.5	7.0	7.0	7.7	0.7
D	3,200[1]	365	1,140	1.0	7.2	7.2	8.0	0.8
E	3,400[1]	400	1,190	0.9	7.5	7.5	8.3	0.8
F	3,600[1]	350	1,115	1.0	7.5	7.5	8.3	0.8
G	3,780[1]	235	725	1.5	7.6	7.6	8.4	0.8
Tennessee Creek								
A	250[2]	195	470	2.0	6.9	6.9	7.9	1.0
B	385[2]	165	480	2.0	7.2	7.2	8.1	0.9
C	1700[2]	185	400	1.9	7.8	7.8	8.6	0.8
D	860[2]	200	360	2.2	7.8	7.8	8.6	0.8
E	955[2]	210	510	1.5	8.9	8.9	9.3	0.4
F	1,100[2]	120	430	1.8	9.1	9.1	9.5	0.4
G	1,300[2]	75	245	3.2	9.2	9.2	9.5	0.3
H	1,700[2]	90	200	3.9	11.1	11.1	11.5	0.4
I	2,015[2]	115	240	3.2	14.1	14.1	15.0	0.9
J	2,430[2]	100	230	3.4	16.1	16.1	16.6	0.5
K	2,715[2]	95	180	4.4	18.1	18.1	18.4	0.3
L	3,080[2]	65	120	6.6	22.3	22.3	23.0	0.7
M	3,220[2]	75	170	4.6	24.3	24.3	24.7	0.4

[1] Feet Above Mouth [2] Feet Above Confluence With Coyote Creek

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

COYOTE CREEK-TENNESSEE CREEK

TABLE 5

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Crest Marin Creek								
A	535	285	640	0.3	7.6	7.6	8.5	0.9
B	795	300	670	0.3	7.7	7.7	8.5	0.8
C	1,050	310	1,035	0.2	7.7	7.7	8.5	0.8
D	1,325	185	395	0.5	7.7	7.7	8.5	0.8
E	1,585	100	130	1.4	8.0	8.0	9.0	1.0
F	1,890	125	200	0.9	9.0	9.0	9.8	0.8
G	2,075	175	220	0.8	9.4	9.4	10.1	0.7

[1]Feet Above Confluence With Tennessee Creek

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

CREST MARIN CREEK

TABLE 5

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NGVD)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Reed Creek								
A	900	380	715	0.6	11.9	11.9	12.9	1.0
B	1,075	160	170	2.6	13.5	13.5	14.3	0.8
C	1,350	95	155	2.8	18.2	18.2	18.7	0.5
D	1,550	30	85	5.1	19.9	19.9	20.4	0.5
E	1,960	15	50	9.0	27.4	27.4	27.7	0.3
F	2,190	20	105	4.0	31.7	31.7	32.2	0.5
G	2,620	25	155	2.7	39.3	39.3	40.3	1.0
H	2,750	20	125	3.4	41.4	41.4	42.2	0.8
I	2,925	25	105	4.1	43.8	43.8	44.3	0.5
Eskoot Creek								
A	2,855	55	235	1.9	6.4	6.4	7.3	0.9
B	3,420	55	220	2.1	8.2	8.2	9.0	0.8
C	3,835	85	230	1.8	10.3	10.3	11.0	0.7
D	5,229	30	90	10.1	31.9	31.9	31.9	0.0
E	5,825	25	60	8.8	52.0	52.0	52.0	0.0

[1] Feet Above Mouth

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FLOODWAY DATA

REED CREEK-ESKOOT CREEK

TABLE 5

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Arroyo San Jose								
A	17,300	62/10[2]	409	5.6	43.1	43.1	43.1	0.0
Lagunitas Creek								
A	910	1,940	9,000	3.0	9.9	9.9	10.9	1.0
B	2,560	2,600	20,880	1.3	10.5	10.5	11.3	0.8
C	5,895	2,500	21,430	1.3	10.6	10.6	11.4	0.8
D	7,840	2,900	20,560	1.4	10.8	10.8	11.6	0.8
E	9,960	1,900	8,100	3.5	11.1	11.1	12.1	1.0
F	12,810	600	3,220	6.4	17.1	17.1	18.1	1.0
G	13,630	500	3,930	5.3	18.6	18.6	19.0	0.4
H	14,890	450	3,950	5.2	19.7	19.7	20.1	0.4
I	15,880	300	3,130	6.6	21.0	21.0	21.4	0.4
J	16,960	300	3,670	5.6	23.0	23.0	23.8	0.8

[1]Feet Above Mouth [2]Width/Width Within County Limits

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MARIN COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

ARROYO SAN JOSE-LAGUNITAS CREEK

TABLE 5

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Olema Creek								
A	1,230	900	2,560	2.2	14.0	12.2[2]	13.0[2]	0.8
B	2,460	740	1,400	4.1	16.0	16.0	16.4	0.4
C	2,890	410	770	7.4	16.6	16.6	17.0	0.4
D	3,970	680	2,360	2.4	20.8	20.8	21.5	0.7
E	5,040	750	1,730	3.3	22.7	22.7	23.5	0.8
F	6,190	700	1,930	3.0	26.2	26.2	26.7	0.5
G	7,240	790	1,320	4.3	30.5	30.5	30.9	0.4
H	7,830	790	1,560	3.7	34.9	34.9	34.9	0.0
I	8,740	860	1,300	4.4	38.7	38.7	39.3	0.6
J	9,560	760	950	6.1	44.5	44.5	44.5	0.0
K	10,240	840	1,380	4.1	48.0	48.0	48.7	0.7
L	10,670	1,290	2,750	2.1	49.6	49.6	50.2	0.6
M	11,260	95	460	12.5	52.5	52.5	52.6	0.1

[1] Feet Above Confluence With Lagunitas Creek

[2] Elevation Computed Without Consideration of Flooding From Lagunitas Creek

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

FLOODWAY DATA

OLEMA CREEK

TABLE 5

The Tennessee Creek floodway deviates from the natural channel downstream of Tennessee Valley Road. The floodflow is much greater than channel capacity, causing the majority of flow to be outside the channel adjacent to Tennessee Valley Road. It is in this area of maximum conveyance that the floodway is shown.

No floodway is shown on Sutton-Manor Creek because the flooding is contained primarily within the channel with only slight shallow flooding overtopping banks.

The Eskoot Creek floodway is divided into an upstream length and a downstream length by a shallow flooding area. No floodway was computed for this shallow flooding area because of the influence of shallow tidal flooding.

Novato Creek floodflows are of the sheetflow type not conducive to the application of floodways. The sheetflow does not return to the channel; rather, it flows into Warner Creek (not studied, inside the City of Novato corporate limits) and follows along the channel as sheetflow. From Warner Creek to San Pablo Bay, floodflows generally are a series of diked or cutoff ponding areas that fill up and spill over into adjacent ponding or diked areas.

Miller Creek floodflows upstream of U.S. Highway 101 are contained within the channel. Downstream of U.S. Highway 101, upstream of the Southern Pacific Railroad, ponding occurs; and, downstream of the Southern Pacific Railroad, estuary flooding occurs. For these areas, no floodway is shown.

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were computed at cross sections. Between cross sections, the boundaries were interpolated. In cases where the floodway and 100-year flood plain boundaries are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and 100-year flood plain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 4.

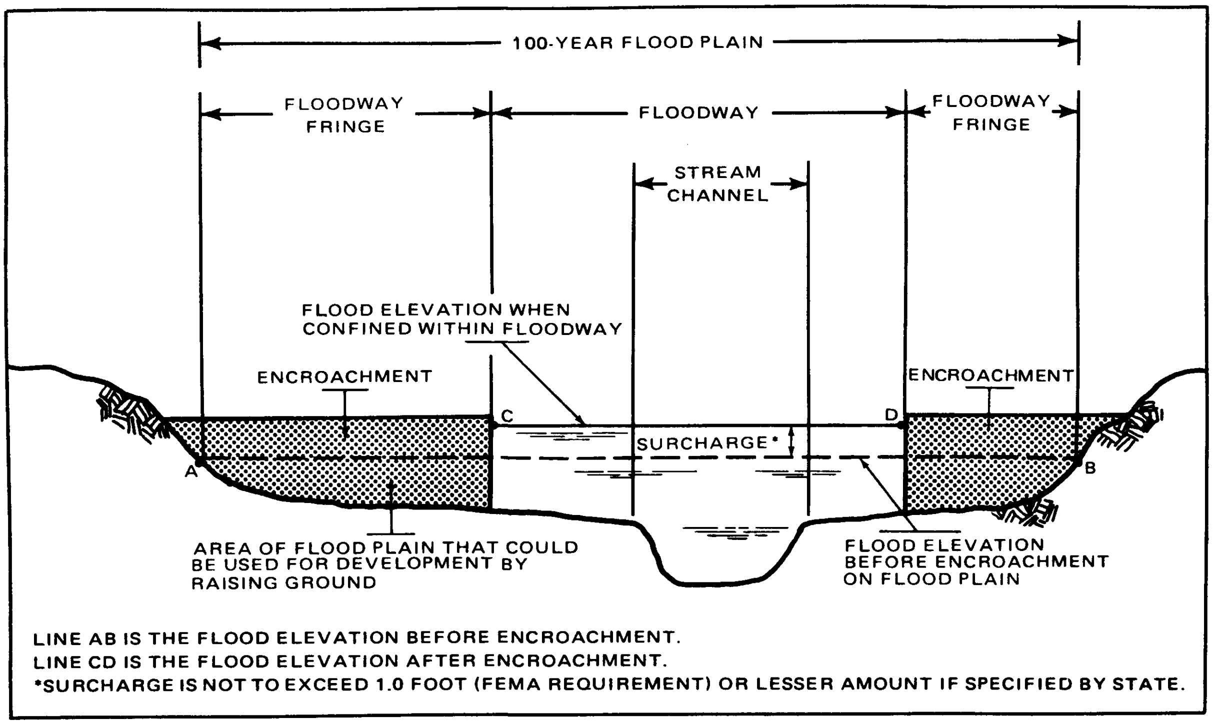

Figure 4. Floodway Schematic

5.0 INSURANCE APPLICATION

To establish actuarial insurance rates, data from the engineering study must be transformed into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail affecting Marin County.

5.1 Reach Determinations

Reaches are defined as sections of flood plain that have relatively the same flood hazard. In riverine areas, reaches are based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference may not have a variation greater than that indicated in the following table for more than 20 percent of the reach:

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the riverine flooding sources of Marin County are shown on the Flood Profiles (Exhibit 1) and summarized in Table 6.

In tidal areas, reaches are limited to the distance for which the 100-year flood elevation does not vary more than 1.0 foot. Using these criteria, 15 reaches were required for the tidal flooding sources of Marin County. The locations of these reaches are shown on the Flood Insurance Rate Map.

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is used to establish relationships between depth and frequency of flooding in any reach. This relationship is then used with depth-damage relationships for various classes of structures to establish actuarial insurance rate tables.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations rounded to the nearest one-half foot, multiplied by 10, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year flood water-surface elevations is greater than 10.0 feet, it is rounded to the nearest whole foot.

5.3 Flood Insurance Zones

Flood insurance zones and zone numbers are assigned based on the type of flood hazard and the FHF, respectively. A unique zone number is associated with each possible FHF, and varies from 1 for a FHF of 005 to a maximum of 30 for a FHF of 200 or greater.

Zone A:	Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or FHFs determined.
Zone V:	Special Flood Hazard Areas along coasts inundated by the 100-year flood, as determined by approximate methods, and that have additional velocity hazards associated with wave action; no base flood elevations shown or FHFs determined.
Zone A0:	Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; depths are shown, but no FHFs are determined.

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION[3] (FEET NGVD)
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
San Pablo Bay							
Reach 1	0140,0145, 0255,0256, 0257,0276 0300	-0.4	N/A	0.2	005	V1	6
Reach 2	0140,0256, 0257,0258, 0259,0267 0269,0276 0300	-0.4	N/A	0.2	005	A1	6
San Francisco Bay							
Reach 1	0444,0455, 0465,0482, 0525	-0.6	N/A	0.3	005	V1	6
Reach 2	0444,0465	-0.6	N/A	0.3	005	A1	6
Bolinas Lagoon							
Reach 1	0420	-0.5	-0.1	0.3	005	A1	6
Reach 2	0419,0420	-0.5	-0.1	0.3	005	A1	6

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

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FLOOD INSURANCE ZONE DATA

SAN PABLO BAY-SAN FRANCISCO BAY-BOLINAS LAGOON

TABLE 6

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION[3] (FEET NGVD)
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Pacific Ocean							
Reach 1	0420	-2.5	-0.6	1.6	025	V5	24
Reach 2	0420	-2.1	-0.6	1.3	020	V4	15
Reach 3	0420	-2.1	-0.6	1.3	020	V4	16
Reach 4	0420	-2.1	-0.6	1.3	020	V4	17
Reach 5	0420	-2.1	-0.6	1.3	020	V4	19
Reach 6	0420	-2.2	-0.5	1.3	020	V4	20
Reach 7	0419,0420	-2.2	-0.4	1.4	020	V4	19
Reach 8	0419	-2.3	-0.4	1.6	025	V5	22
Reach 9	0419	-2.3	-0.5	1.5	025	V5	23
Shallow Flooding	0419	N/A	N/A	N/A	N/A	A0	Depth 3

[1] Flood Insurance Rate Map Panel [2] Weighted Average [3] Rounded to Nearest Foot

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FLOOD INSURANCE ZONE DATA

PACIFIC OCEAN

TABLE 6

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND 10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)	FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION[3] (FEET NGVD)
Novato Creek							
Reach 1	0258,0259	-1.1	-0.2	0.0	010	A2	Varies - See Map
Reach 2	0251	-2.8	-0.9	0.9	030	A6	Varies - See Map
Reach 3	0232,0251	-2.04	-0.8	1.29	020	A4	Varies - See Map
Arroyo San Jose							
Reach 1	0258	-2.5	-1.1	1.1	025	A5	Varies - See Map
Ponding Area	0258,0259	-2.2	-0.2	0.3	020	A4	8
Miller Creek							
Reach 1	0266,0267 0268,0269	-0.3	-0.1	0.3	005	A1	Varies - See Map
Reach 2	0266,0268	-1.7	-0.4	0.6	015	A3	Varies - See Map
Reach 3	0268	-2.2	-0.5	0.8	020	A4	Varies - See Map
Reach 4	0268	-1.3	-0.3	0.5	015	A3	Varies - See Map
Reach 5	0266,0268	-1.1	-0.3	0.4	010	A2	Varies - See Map
Reach 6	0268	-1.8	-0.4	0.6	020	A4	Varies - See Map
Reach 7	0261,0262 0264,0268	-1.3	-0.3	0.5	015	A3	Varies - See Map
Lagunitas Creek							
Reach 1	0204,0208 0212,0216	-2.4	-0.4	0.8	025	A5	Varies - See Map
Olema Creek							
Reach 1	0216	-0.9	-0.2	0.4	010	A2	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
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FLOOD INSURANCE ZONE DATA

NOVATO CREEK-ARROYO SAN JOSE-MILLER CREEK-LAGUNITAS CREEK-OLEMA CREEK

TABLE 6

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION[3] (FEET NGVD)
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Coyote Creek							
Reach 1	0443,0444	-1.6	-0.4	0.8	015	A3	Varies - See Map
Tennessee Creek							
Reach 1	0444,0482	-1.0	-0.3	0.7	010	A2	Varies - See Map
Reach 2	0482	-0.4	-0.1	0.2	005	A1	Varies - See Map
Crest Marin Creek							
Reach 1	0443,0444	-0.4	-0.1	0.4	005	A1	Varies - See Map
Shallow Flooding	0443,0444	N/A	N/A	N/A	N/A	AH	8
Reed Creek							
Reach 1	0443	-0.9	-0.3	0.2	010	A2	Varies - See Map
Reach 2	0443	-0.4	-0.1	0.2	005	A1	Varies - See Map
Reach 3	0443	-1.1	-0.3	0.5	010	A2	Varies - See Map
Reach 4	0443	-1.5	-0.4	0.7	015	A3	Varies - See Map
Reach 5	0443	-2.3	-0.7	1.4	025	A5	Varies - See Map
Shallow Flooding	0443	N/A	N/A	N/A	N/A	A0	Depth 2
Sutton-Manor Creek							
Reach 1	0444	-2.3	-0.9	0.6	025	A5	Varies - See Map
Shallow Flooding	0442,0444	N/A	N/A	N/A	N/A	A0	Depth 2
Eskoot Creek							
Reach 1	0419	-0.4	-0.1	0.3	005	A1	Varies - See Map
Shallow Flooding	0419	N/A	N/A	N/A	N/A	A0	Depth 1
Reach 2	0419	-0.9	-0.2	0.5	010	A2	Varies - See Map

[1] Flood Insurance Rate Map Panel [2] Weighted Average [3] Rounded to Nearest Foot

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

FLOOD INSURANCE ZONE DATA

COYOTE CREEK—TENNESSEE CREEK—CREST MARIN CREEK—REED CREEK—SUTTON-MANOR CREEK—ESKOOT CREEK

TABLE 6

Zone AH:	Special Flood Hazard Areas inundated by types of 100-year shallow flooding where depths are between 1.0 and 3.0 feet; base flood elevations are shown, but no FHFs are determined.
Zones A1-A6:	Special Flood Hazard Areas inundated by the 100-year flood; with base flood elevations shown, and zones subdivided according to FHFs.
Zones V1, V4, and V5:	Special Flood Hazard Areas along coasts inundated by the 100-year flood that have additional velocity hazards associated with waves of 3-foot amplitude or greater; with base flood elevations shown, and zones subdivided according to FHFs.
Zone B:	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood; areas that are protected from the 100- or 500-year floods by dike, levee, or other local water-control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flood hazard; not subdivided.
Zone D:	Areas of undetermined, but possible flood hazard.

The flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community are summarized in Table 6.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for Marin County is, for insurance purposes, the principal product of the Flood Insurance Study. This map contains the official delineation of flood insurance zones and base flood elevations. Base flood elevation lines show the locations of the expected whole-foot water-surface elevation of the base (100-year) flood. The base flood elevations and zone numbers are used by insurance agents, in conjunction with structure elevations and characteristics, to assign actuarial insurance rates to structures and contents insured under the NFIP.

6.0 OTHER STUDIES

A Flood Hazard Boundary Map for the unincorporated areas of Marin County, California, was published in 1977 (Reference 26). This study is more detailed and thus supersedes the Flood Hazard Boundary Map.

A Flood Insurance Study was completed for the unincorporated areas of Marin County in 1972 (Reference 5). That study was consulted for this study and is superseded by the results of this Flood Insurance Study.

Flood Insurance Studies have also been published for the Cities of Mill Valley (Reference 7), Novato (Reference 8), and Belvedere (Reference 27), the Towns of Fairfax (Reference 28) and Corte Madera (Reference 29), the City of Larkspur (Reference 30), the Town of Ross (Reference 31), the Cities of San Anselmo (Reference 32), Sausalito (Reference 33), Tiburon (Reference 34), and San Rafael (Reference 35), and the unincorporated areas of Sonoma County, California (Reference 36). The results of those studies match this Flood Insurance Study.

7.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting FEMA, Mitigation Division, The Presidio of San Francisco, Building 105, San Francisco, California 94129-1250.

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9.0 REVISION DESCRIPTIONS

This section has been added to provide information regarding significant revisions made since the original Flood Insurance Study was printed. Future revisions may be made that do not result in the republishing of the Flood Insurance Study report. To ensure that any user is aware of all revisions, it is advisable to contact the community repository of flood hazard data at the Marin County Department of Public Works, 3501 Civic Center Drive, Room 304, San Rafael, California 94913-4186.

9.1 First Revision

This study was revised on May 5, 1997, to show modifications to the flooding along Miller Creek from U.S. Highway 101 to the Southern Pacific Railroad. The hydrologic and hydraulic analyses for this revision were performed for FEMA by Ensign & Buckley, Consulting Engineers, under Contract No. EMW-90-C-3133.

The results of this revision were reviewed at a final Consultation Coordination Officer (CCO) meeting held on March 20, 1996, and attended by representatives of FEMA, Marin County, and the City of San Rafael. All problems raised at that meeting have been addressed in this study.

A HEC-1 model (Reference 37) developed for Miller Creek as described in a previously published Flood Insurance Study for the unincorporated areas of Marin County, California (Reference 38), was used as the basis for the hydrology for this study. The revised portion of Miller Creek is a perched channel. During the 100-year flood event, flow leaves the channel into the adjacent overbanks and forms two additional flow paths referred to as the Left and Right Overbank Channels, respectively. The above-mentioned HEC-1 model was modified to incorporate the effects of these flow splits and the on-site flows as they impact the Left and Right Overbank Channels. The overflow from Miller Creek was modeled using the HEC-1 diversion option based on a discharge-diversion rating determined by a HEC-2 (Reference 39) multiple-discharge, split-flow analysis. This split flow was combined with on-site runoff and routed through a ponded storage area upstream of the railroad. Note that the flow diverted into the Left and Right Overbank Channels does not use the same crossing under the Southern Pacific Railroad as the main channel.

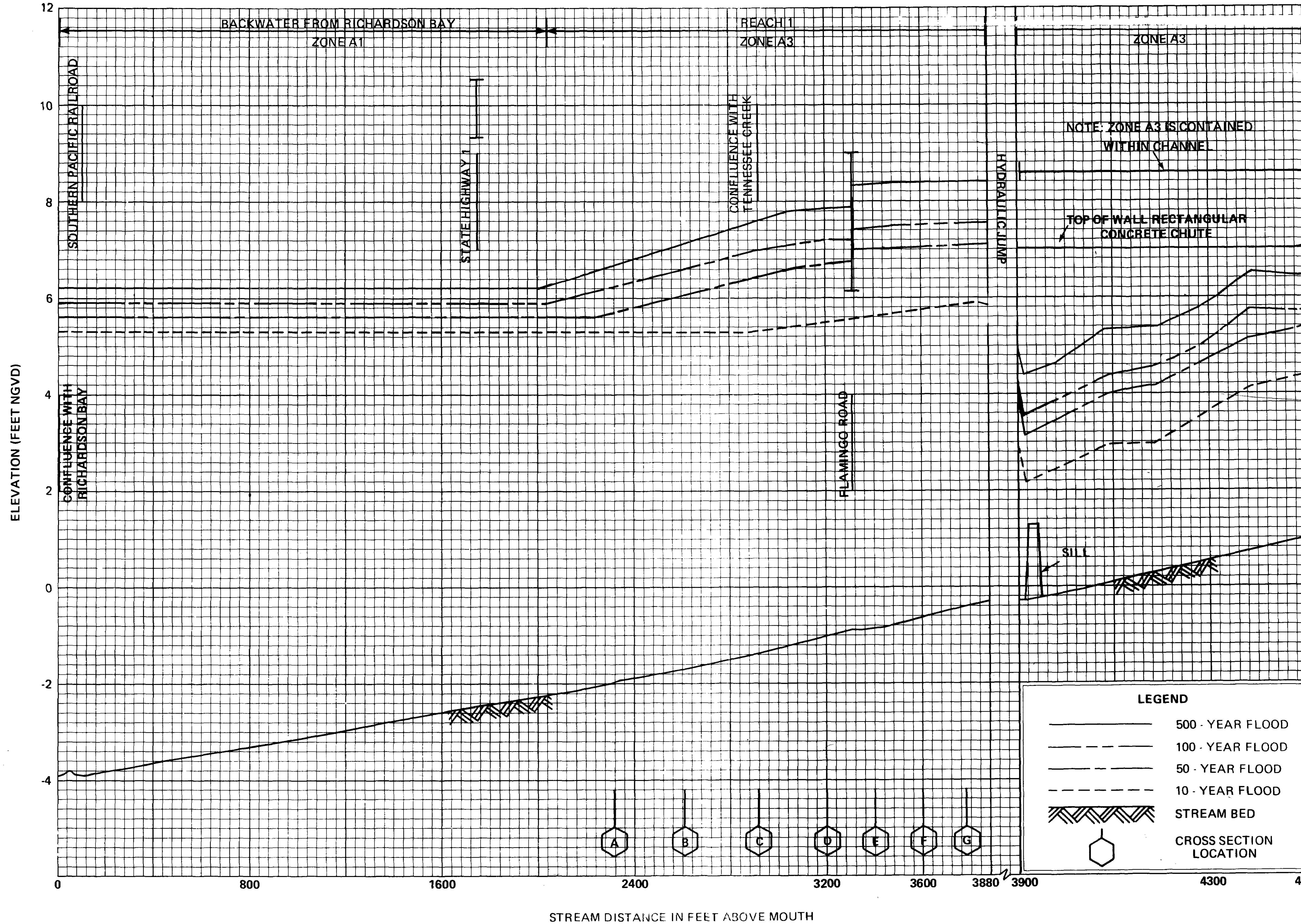
The cross-sectional data used to model Miller Creek and the Left and Right Overbank Channels were taken from field surveys and topographic mapping at a scale of 1:4,800, with a contour interval of 2 feet (Reference 40).

Water-surface elevations of the floods of the selected recurrence intervals were computed using HEC-2. Between cross sections, the 100-year flood plain boundary was interpolated using topographic mapping at a scale of 1:4,800, with a contour interval of 2 feet (Reference 41). The elevations of the ponded areas located upstream of the Southern Pacific Railroad were based on the maximum stage calculated in the storage routing performed in the above-mentioned HEC-1 model.

Channel roughness factors (Manning's "n") used in the hydraulic analysis of Miller Creek were based on field observations and guidelines published by the U.S. Geological Survey (Reference 42). The adopted roughness values for the channel and overbank areas were 0.04 and 0.05, respectively.

Levees are along both banks of the revised portion of Miller Creek. These levees do not have sufficient freeboard to be certified as providing protection from the 100-year flood event. Therefore, with- and without-levee analyses were performed. It was necessary to perform a split-flow analysis for both the with- and without-levee conditions to determine the amount of flow that escapes into the Left and Right Overbank Channels.

A Flood Insurance Study for the City of San Rafael, California (Reference 43), has been prepared and is in agreement with this study.



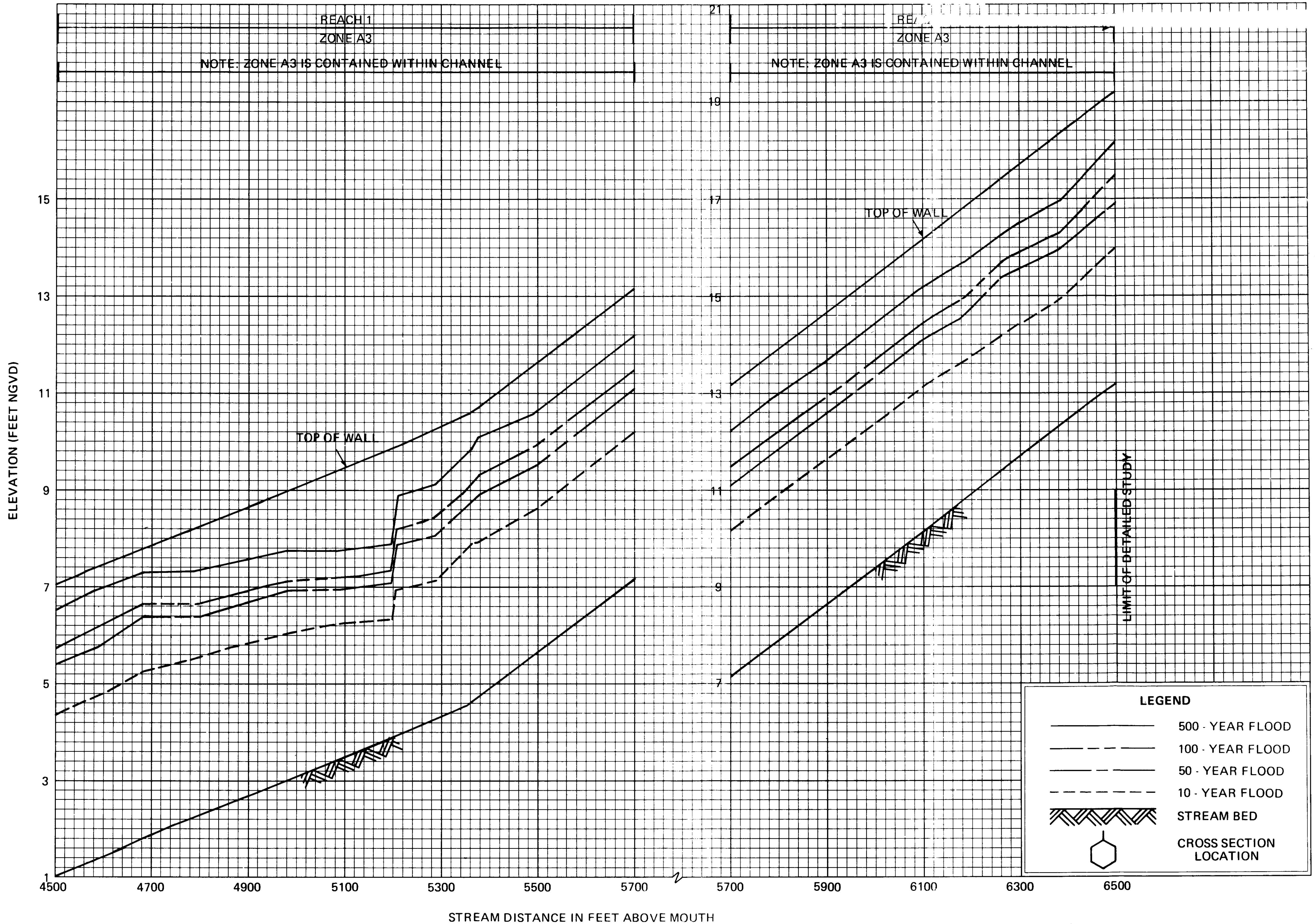
FLOOD PROFILES

COYOTE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

01P



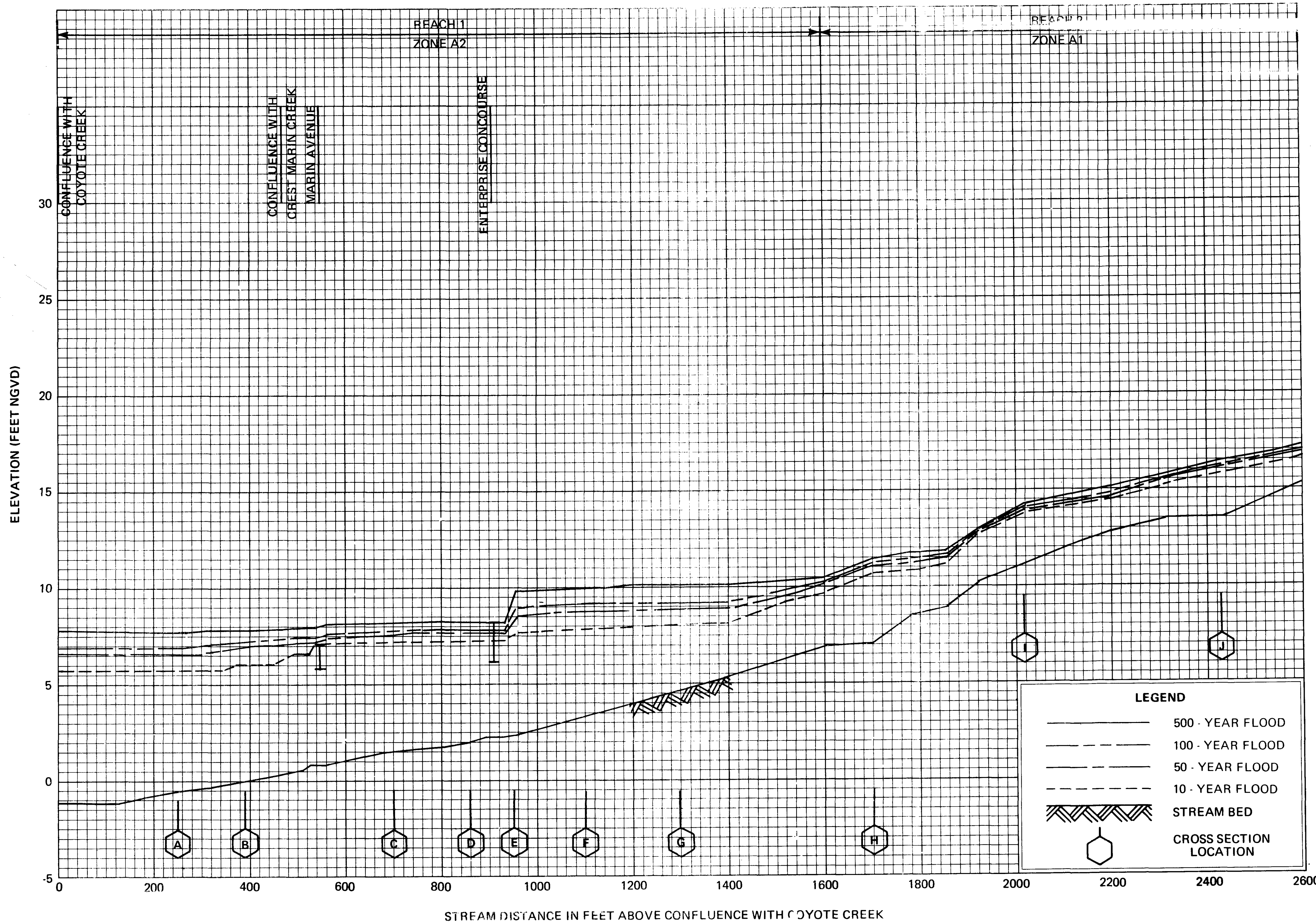
FLOOD PROFILES

COYOTE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

02P



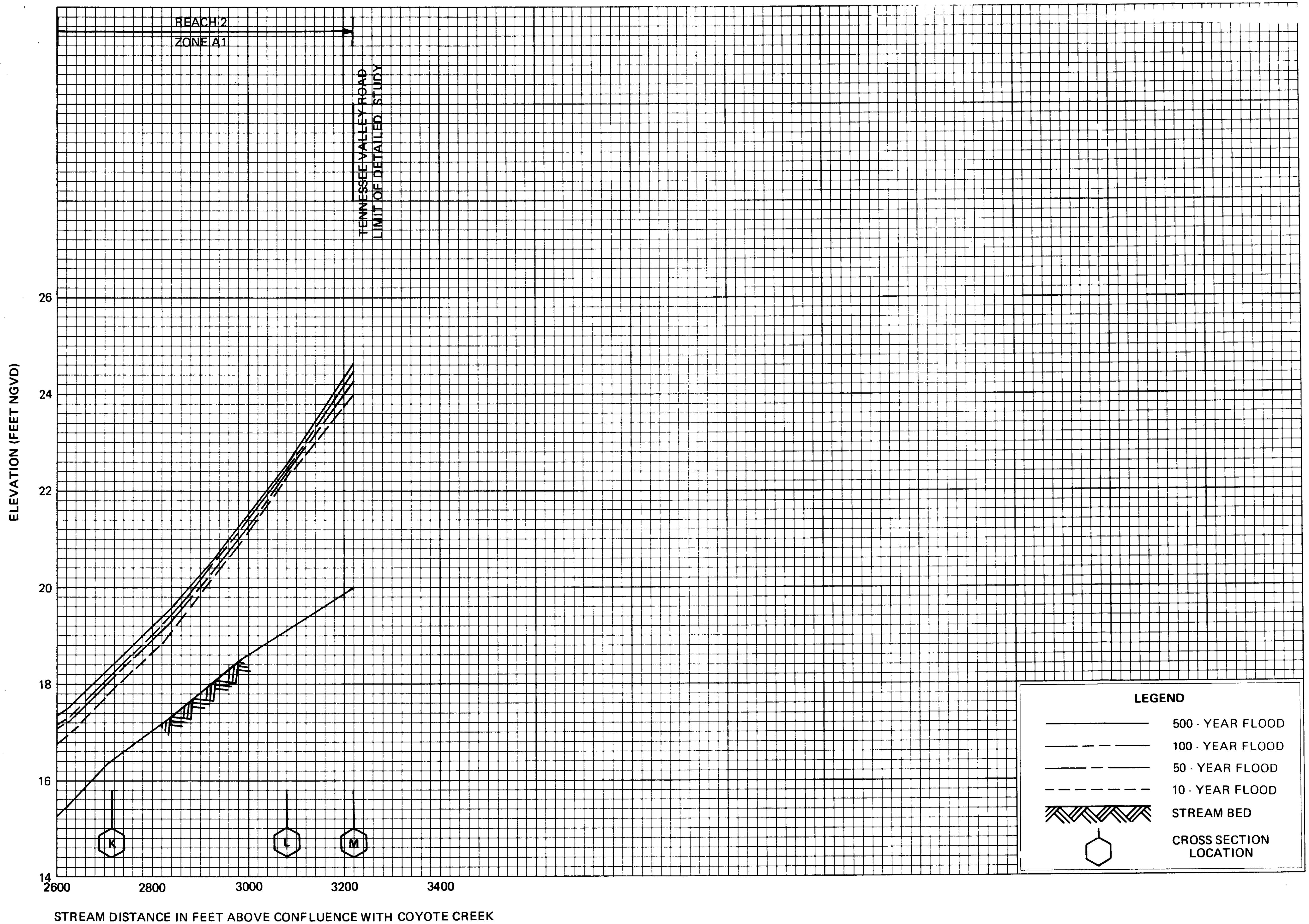
FLOOD PROFILES

TENNESSEE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

03P



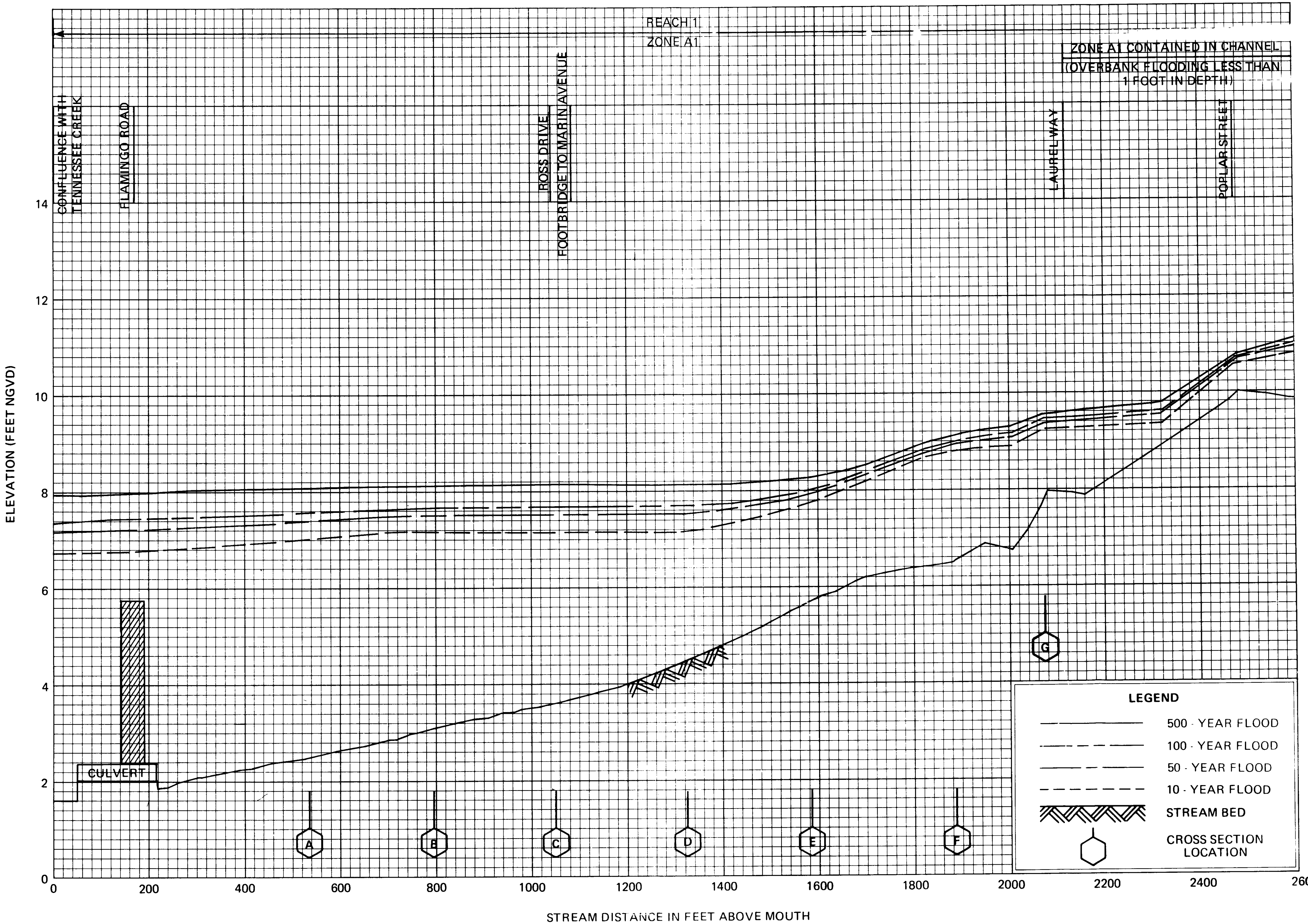
FLOOD PROFILES

TENNESSEE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

04P



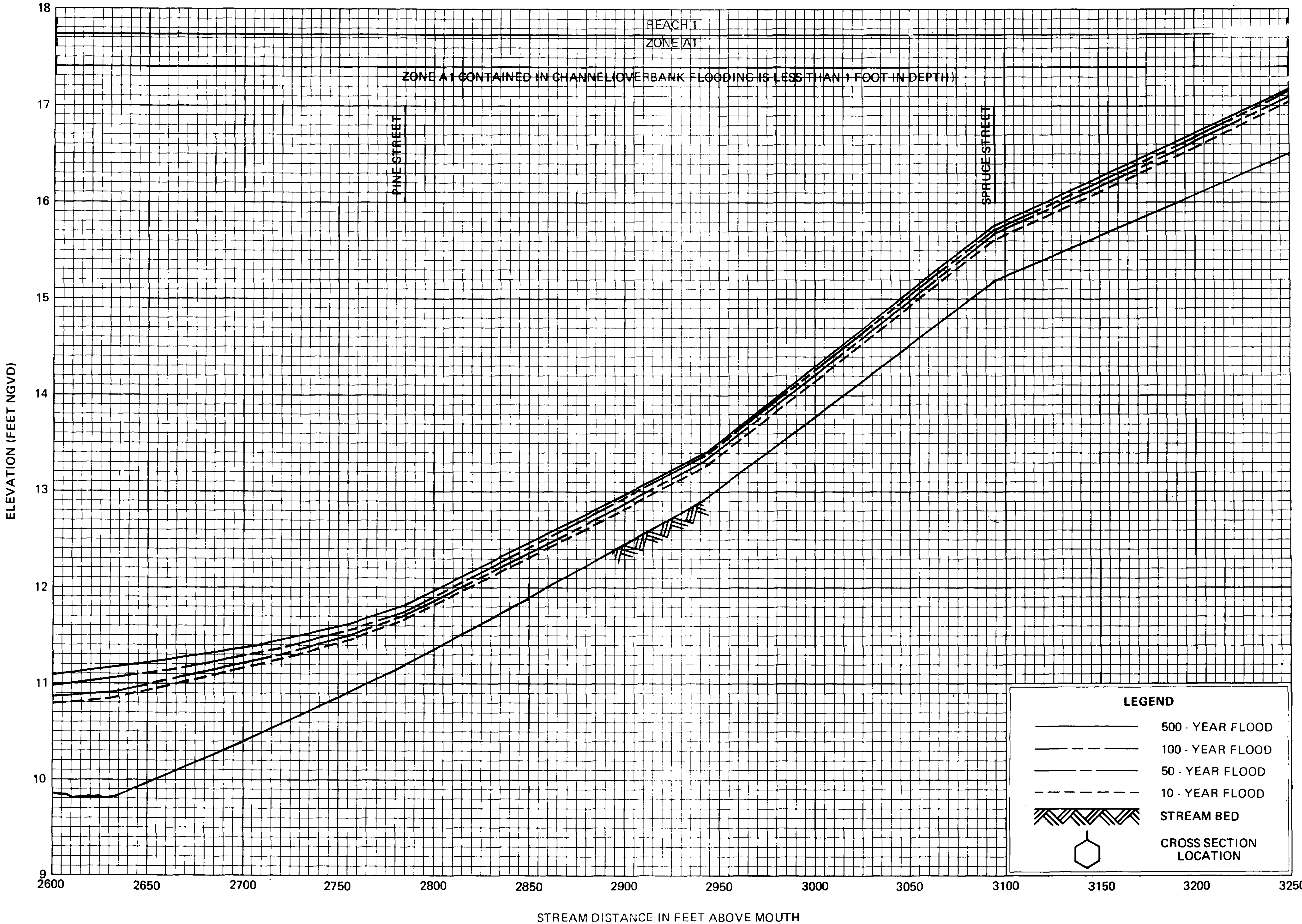
FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

FLOOD PROFILES

CREST MARIN CREEK

05P



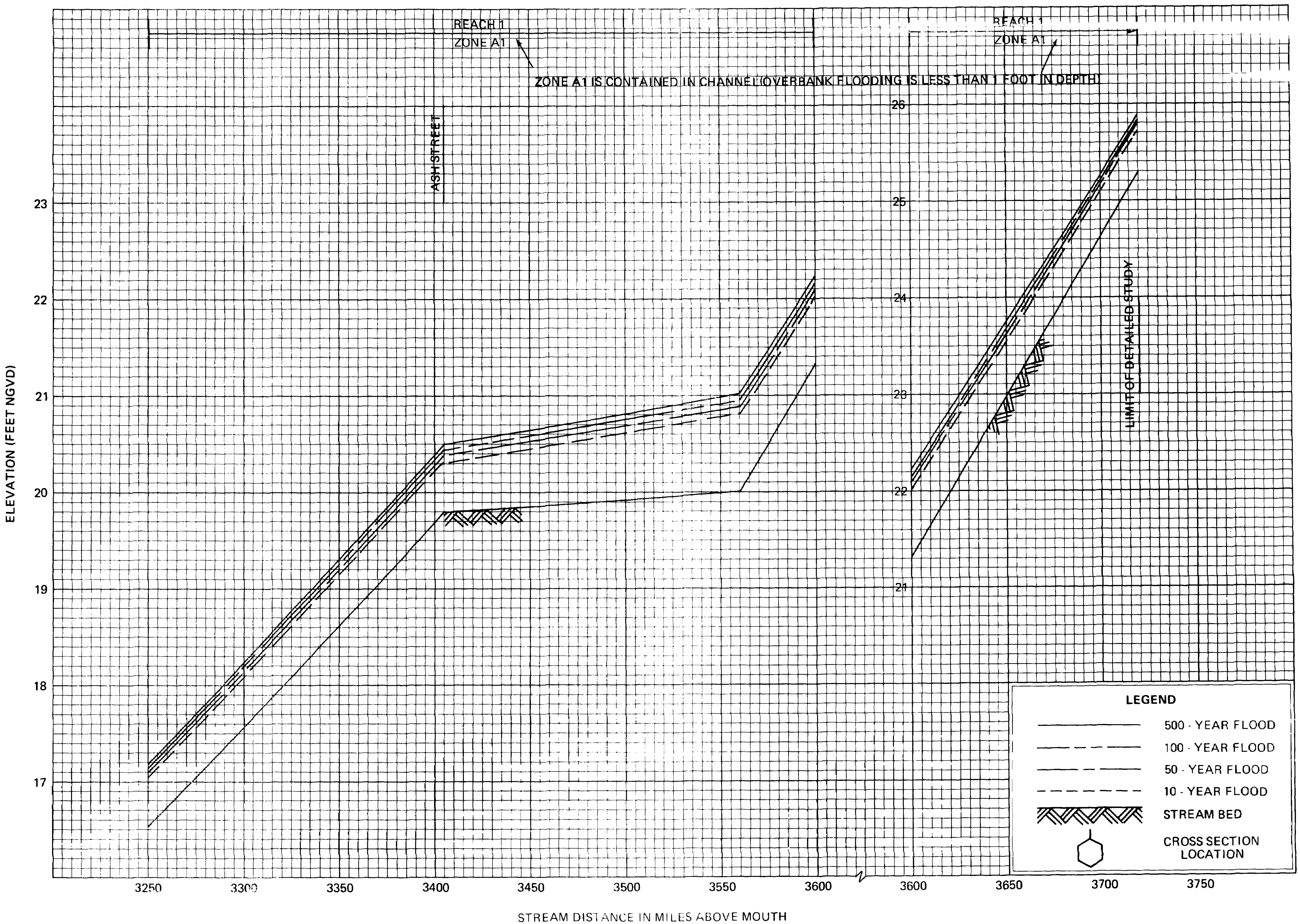
FLOOD PROFILES

CREST MARIN CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

06P



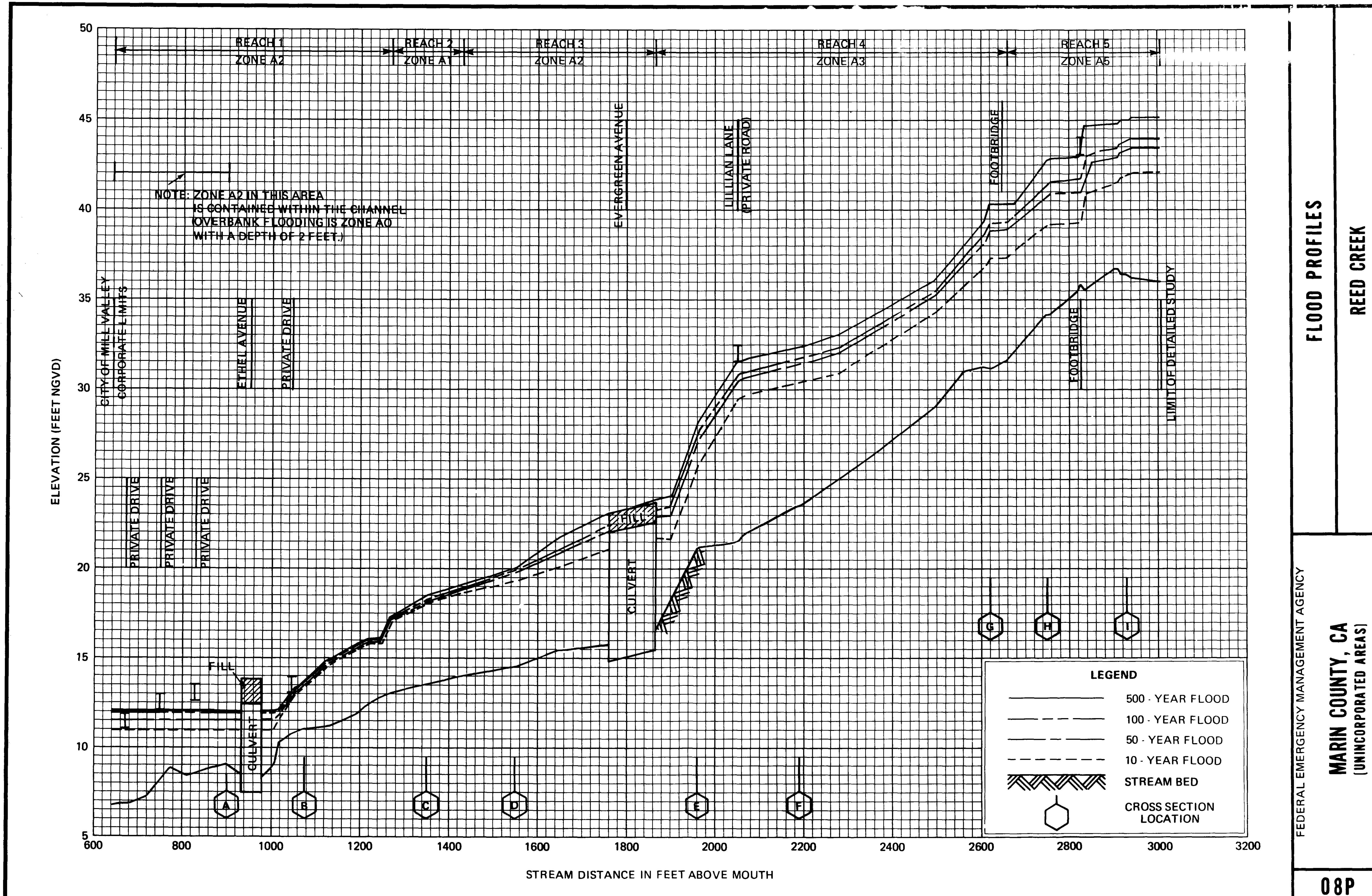
FEDERAL EMERGENCY MANAGEMENT AGENCY

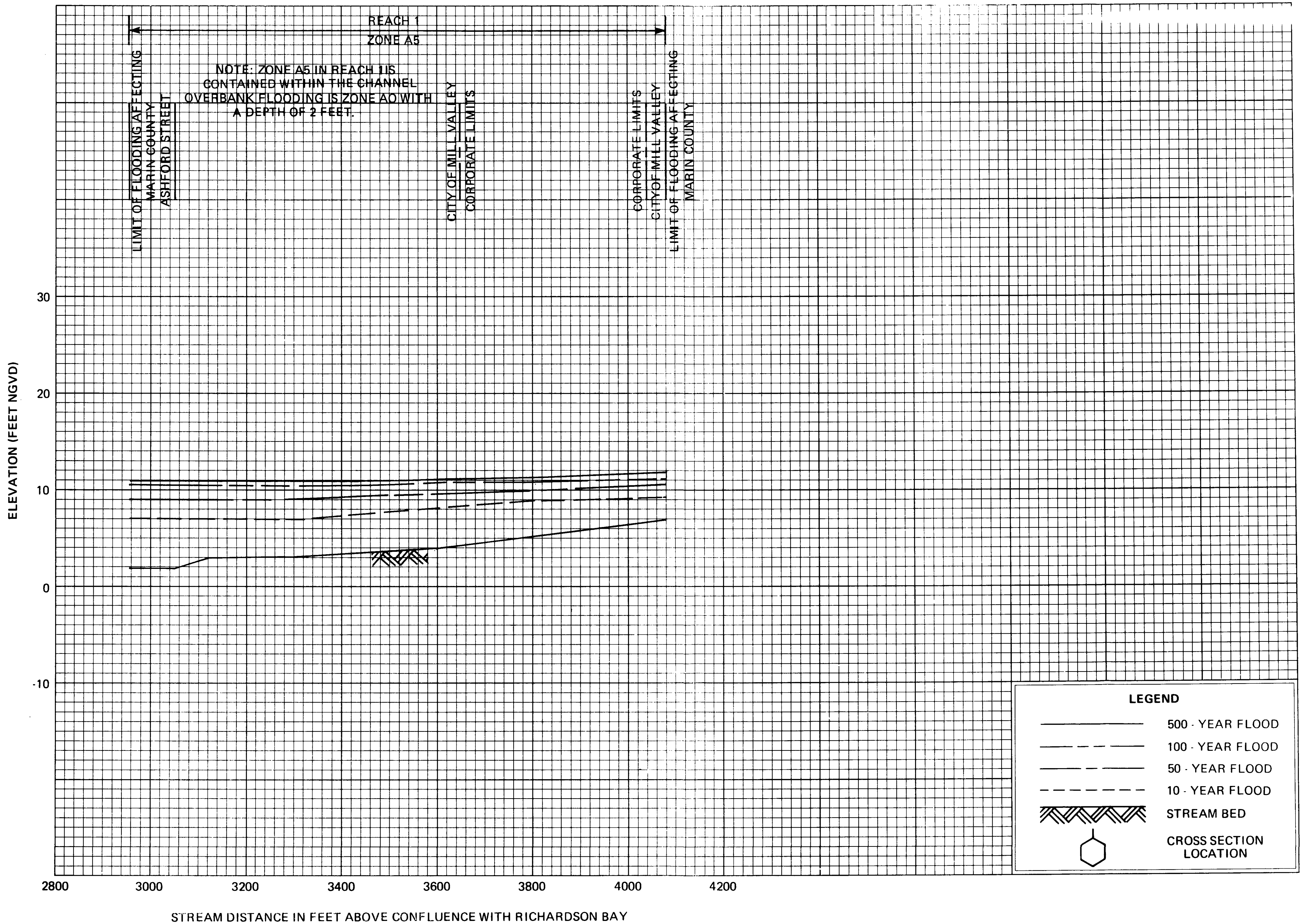
MARIN COUNTY, CA
(UNINCORPORATED AREAS)

FLOOD PROFILES

CREST MARIN CREEK

07P


REACH 1
ZONE A2
REACH 2
ZONE A1
REACH 3
ZONE A2
REACH 4
ZONE A3
REACH 5
ZONE A5
NOTE: ZONE A2 IN THIS AREA IS CONTAINED WITHIN THE CHANNEL (OVERBANK FLOODING IS ZONE AO WITH A DEPTH OF 2 FEET.)
CITY OF MILL VALLEY CORPORATE LIMITS
ETHEL AVENUE
PRIVATE DRIVE
EVERGREEN AVENUE
LILLIAN LANE (PRIVATE ROAD)
FOOTBRIDGE
LIMIT OF DETAILED STUDY
FILL
CULVERT
ELEVATION (FEET NGVD)
STREAM DISTANCE IN FEET ABOVE MOUTH
LEGEND
500 - YEAR FLOOD
100 - YEAR FLOOD
50 - YEAR FLOOD
10 - YEAR FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
REED CREEK
FEDERAL EMERGENCY MANAGEMENT AGENCY
MARIN COUNTY, CA
(UNINCORPORATED AREAS)
08P



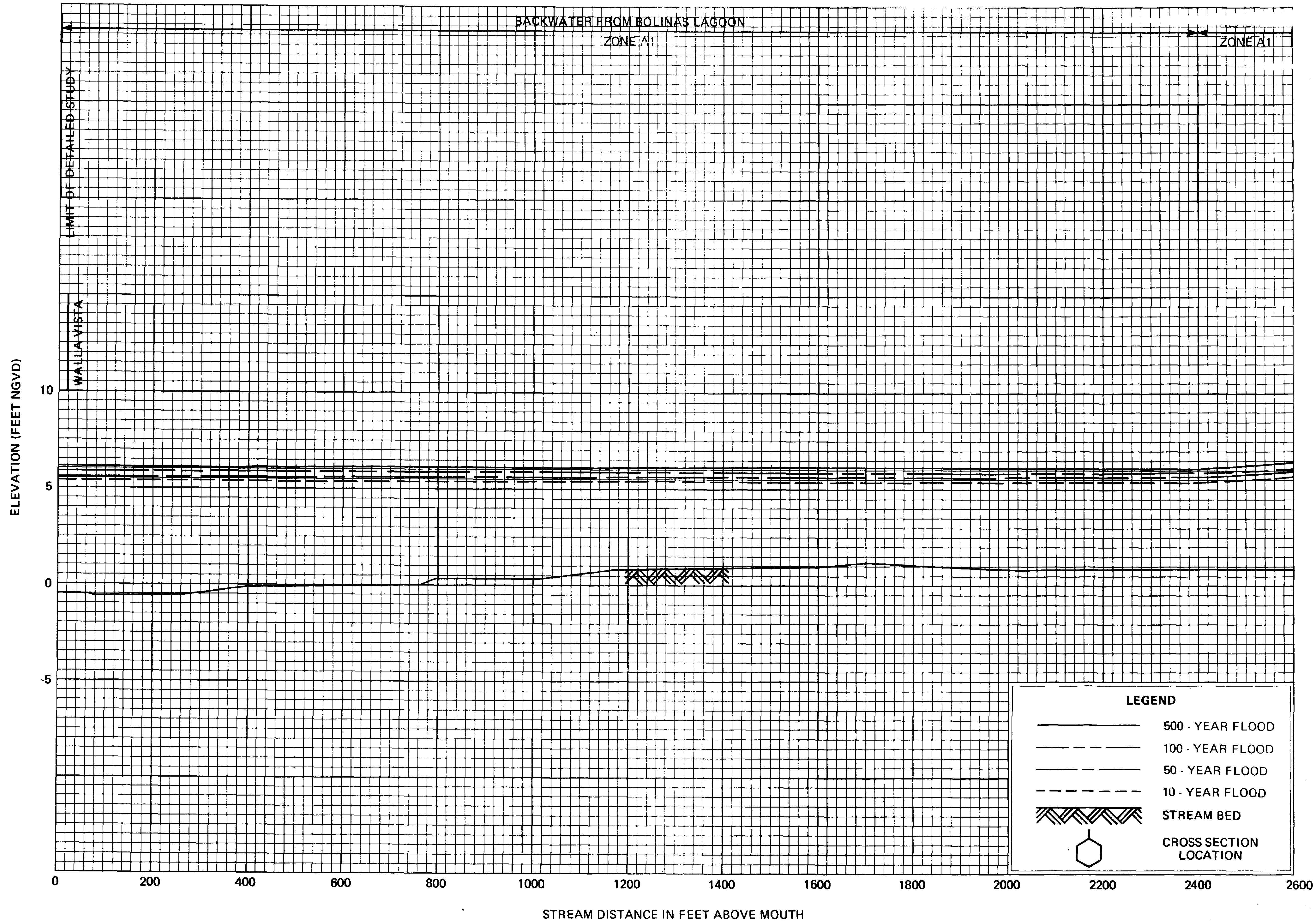
FLOOD PROFILES

SUTTON-MANOR CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

09P



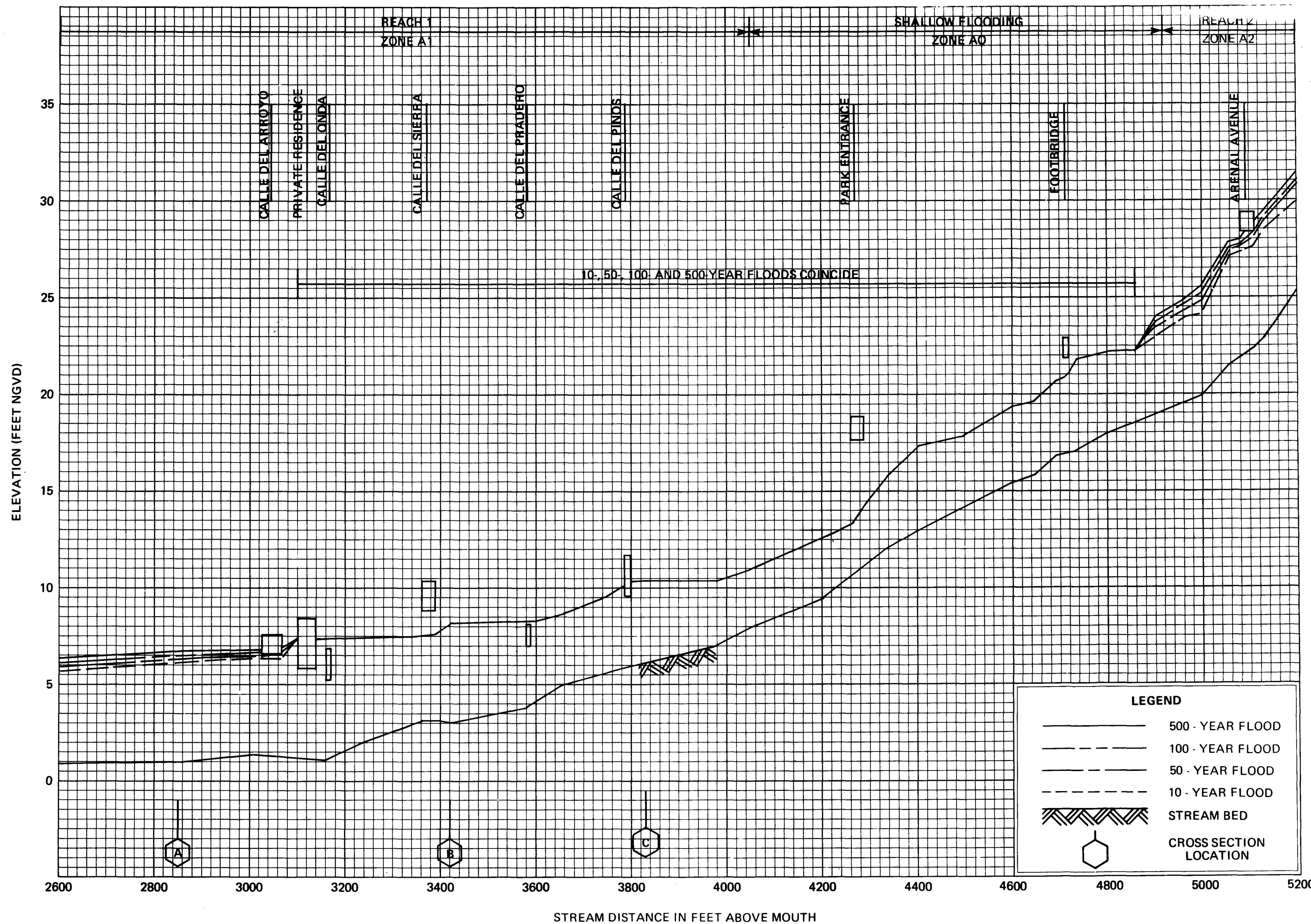
FLOOD PROFILES

ESKOOT CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

10P

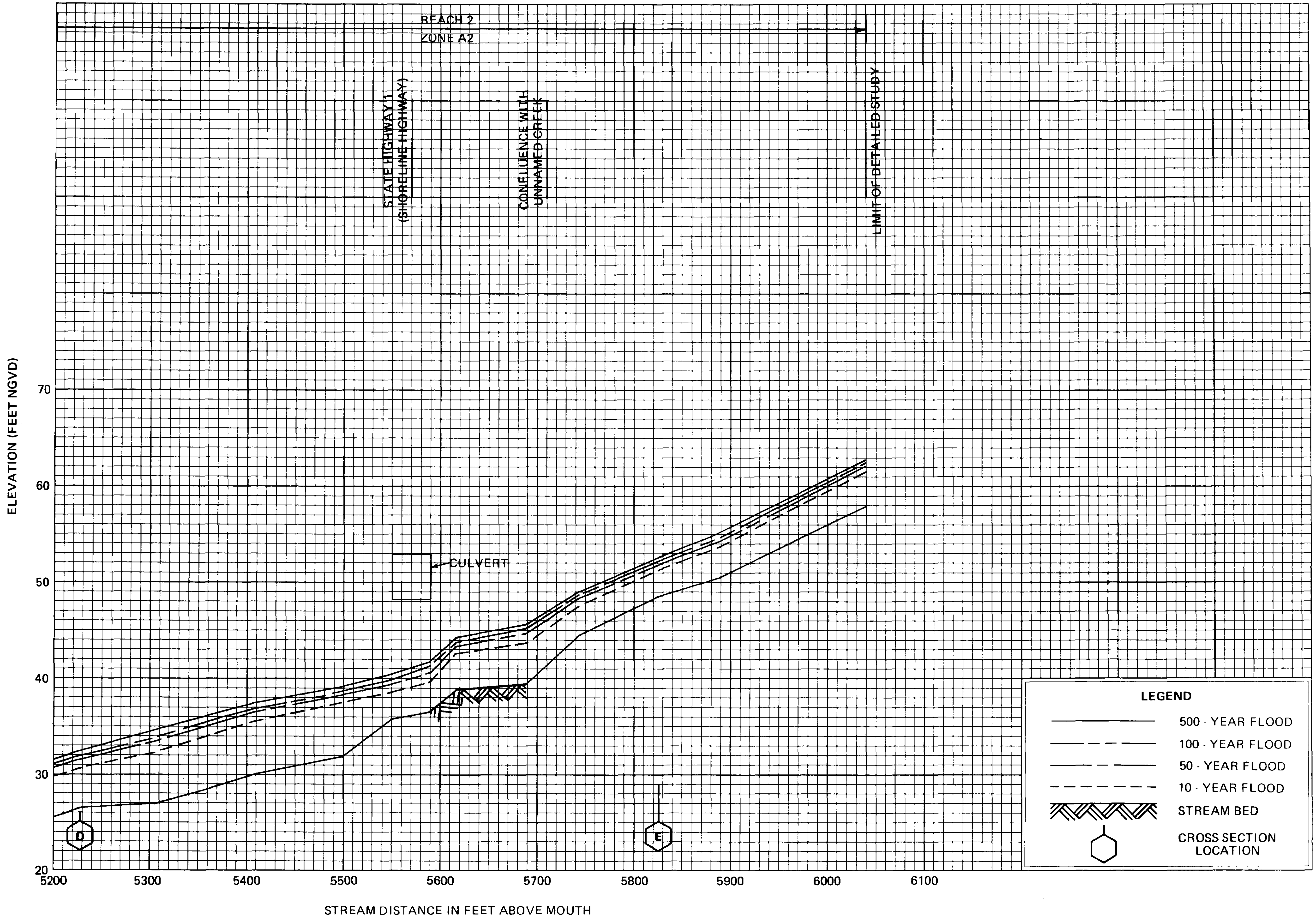


FLOOD PROFILES

ESKOOT CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

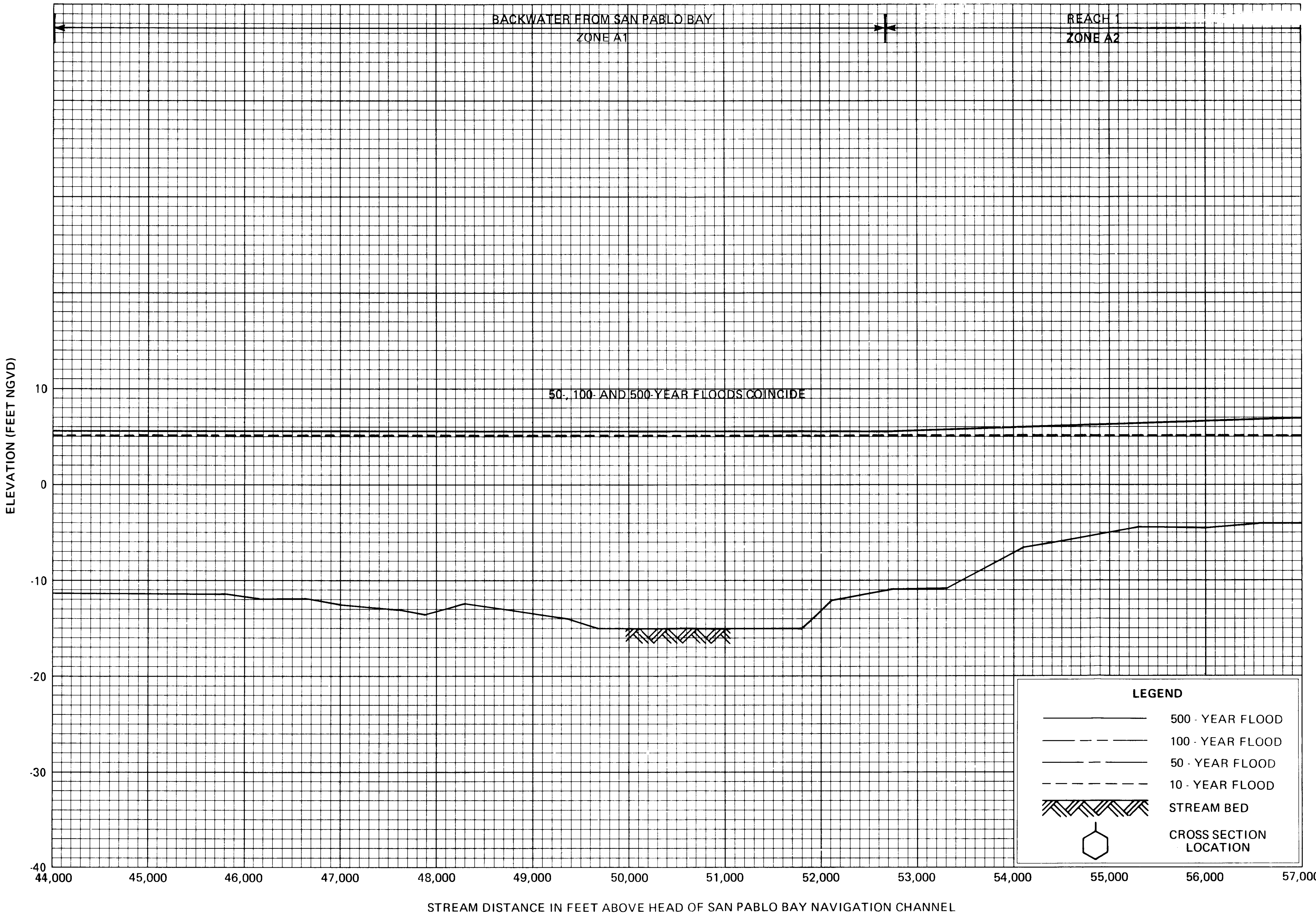


FLOOD PROFILES

ESKOOT CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)



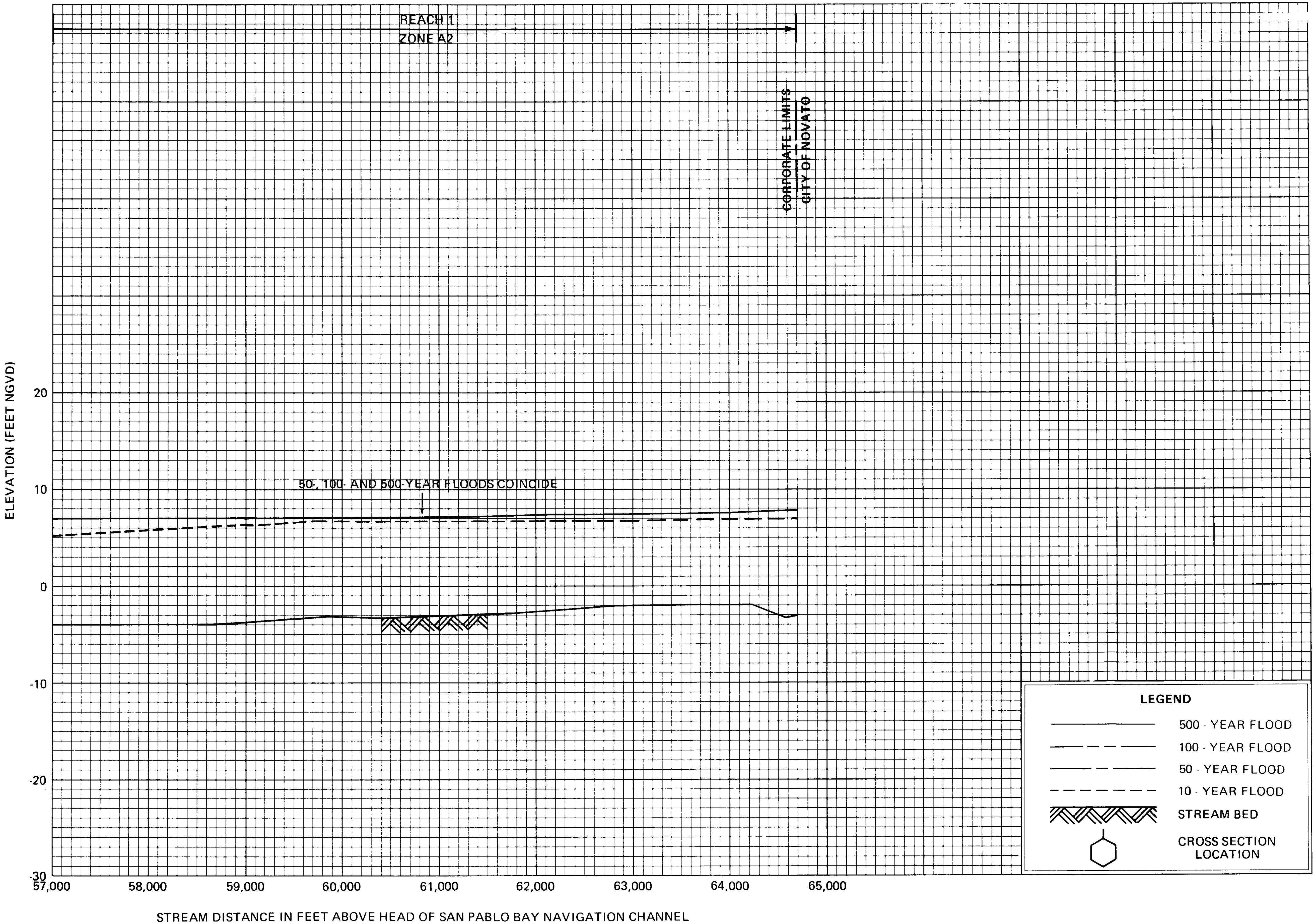
FLOOD PROFILES

NOVATO CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA

(UNINCORPORATED AREAS)



FLOOD PROFILES

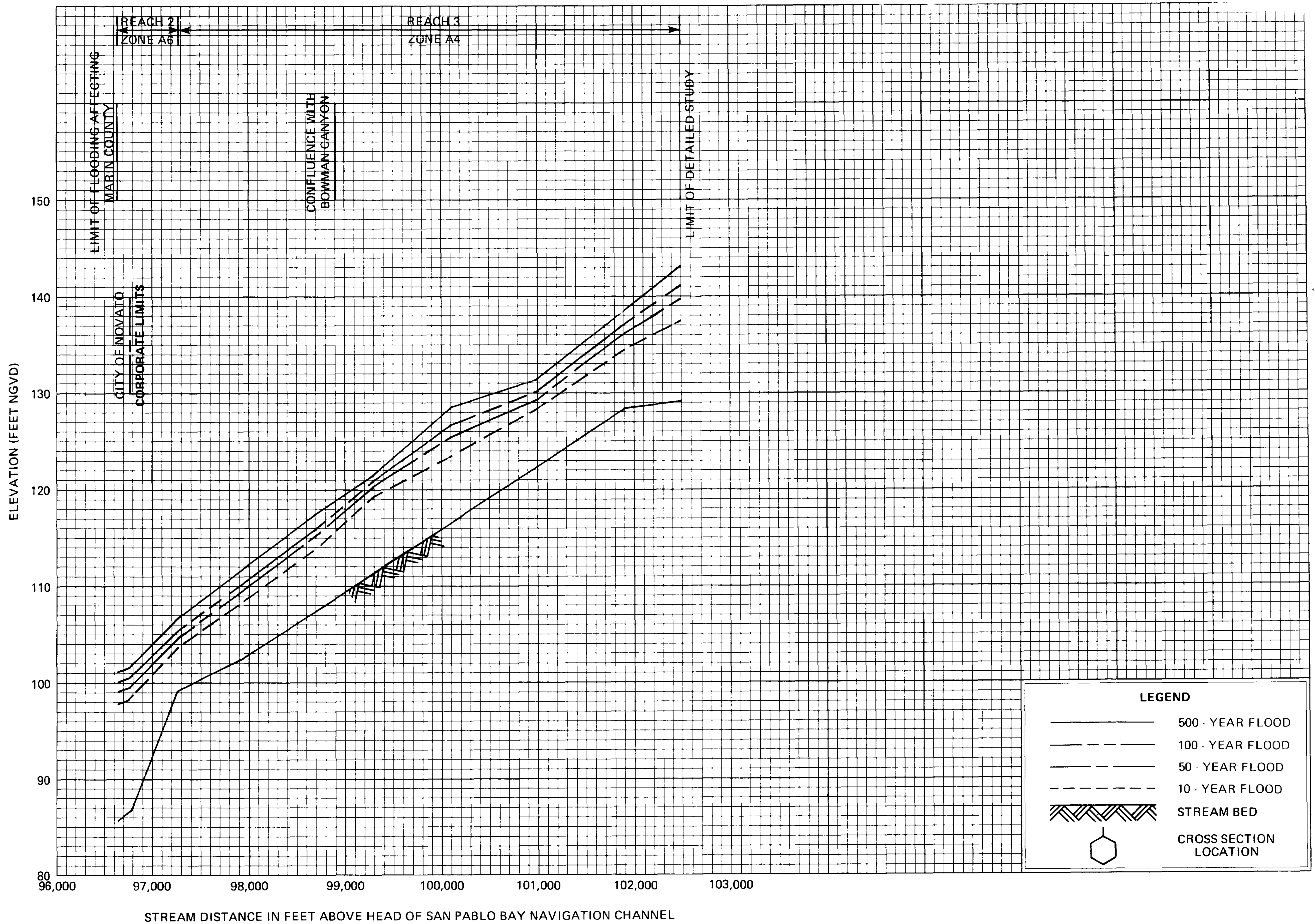
NOVATO CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA

(UNINCORPORATED AREAS)

14P

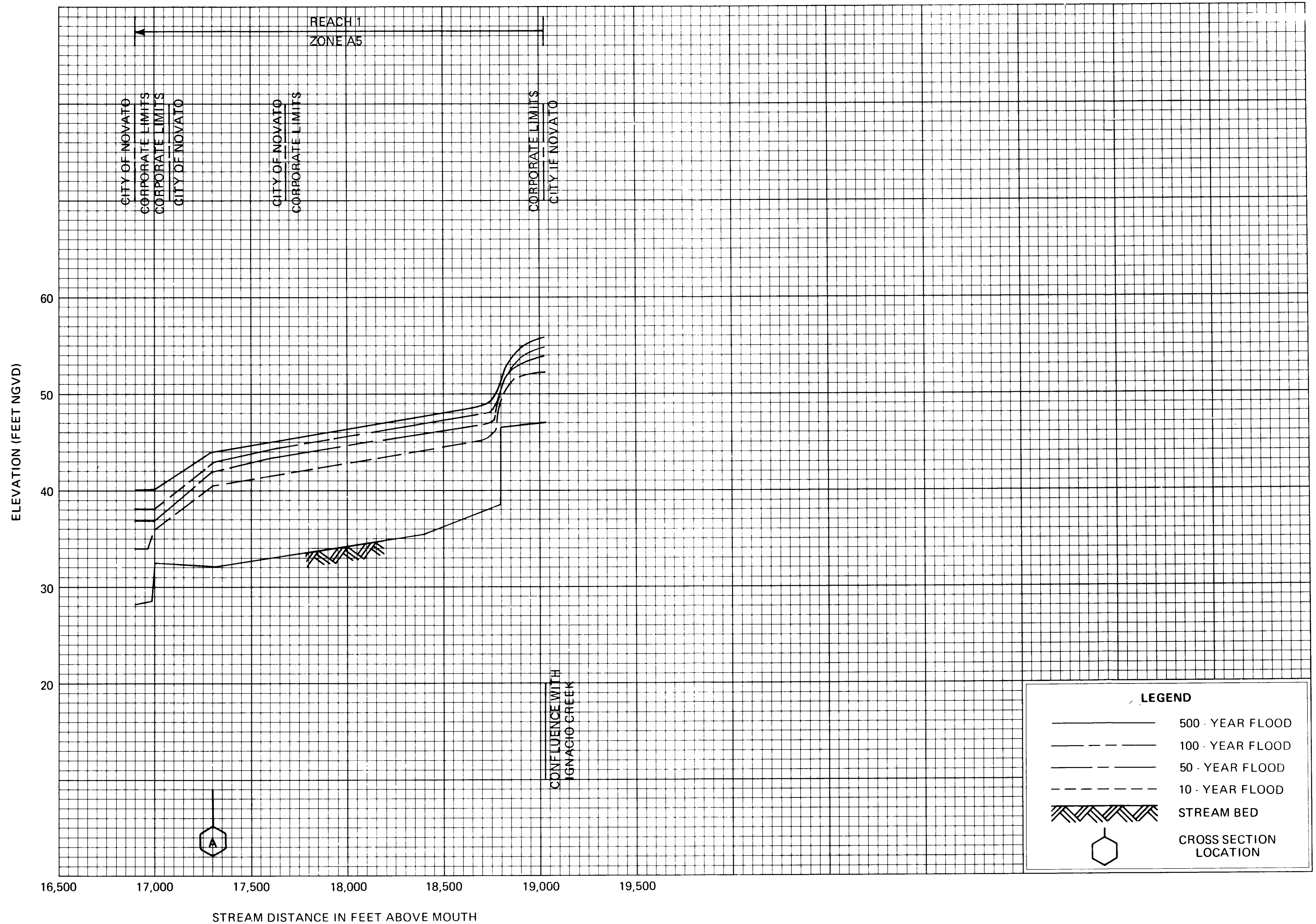


FLOOD PROFILES

NOVATO CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

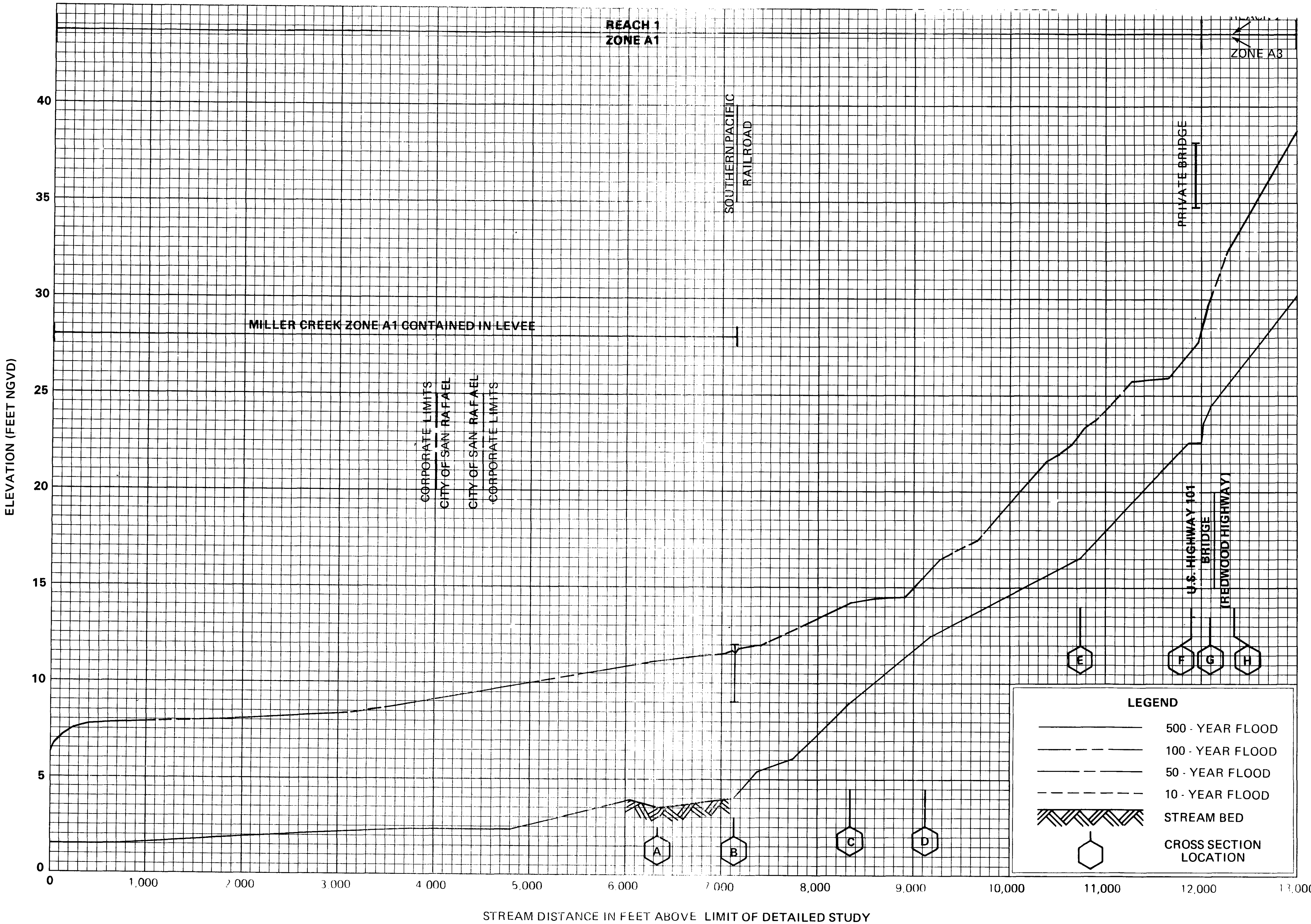


FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

FLOOD PROFILES

ARROYO SAN JOSE



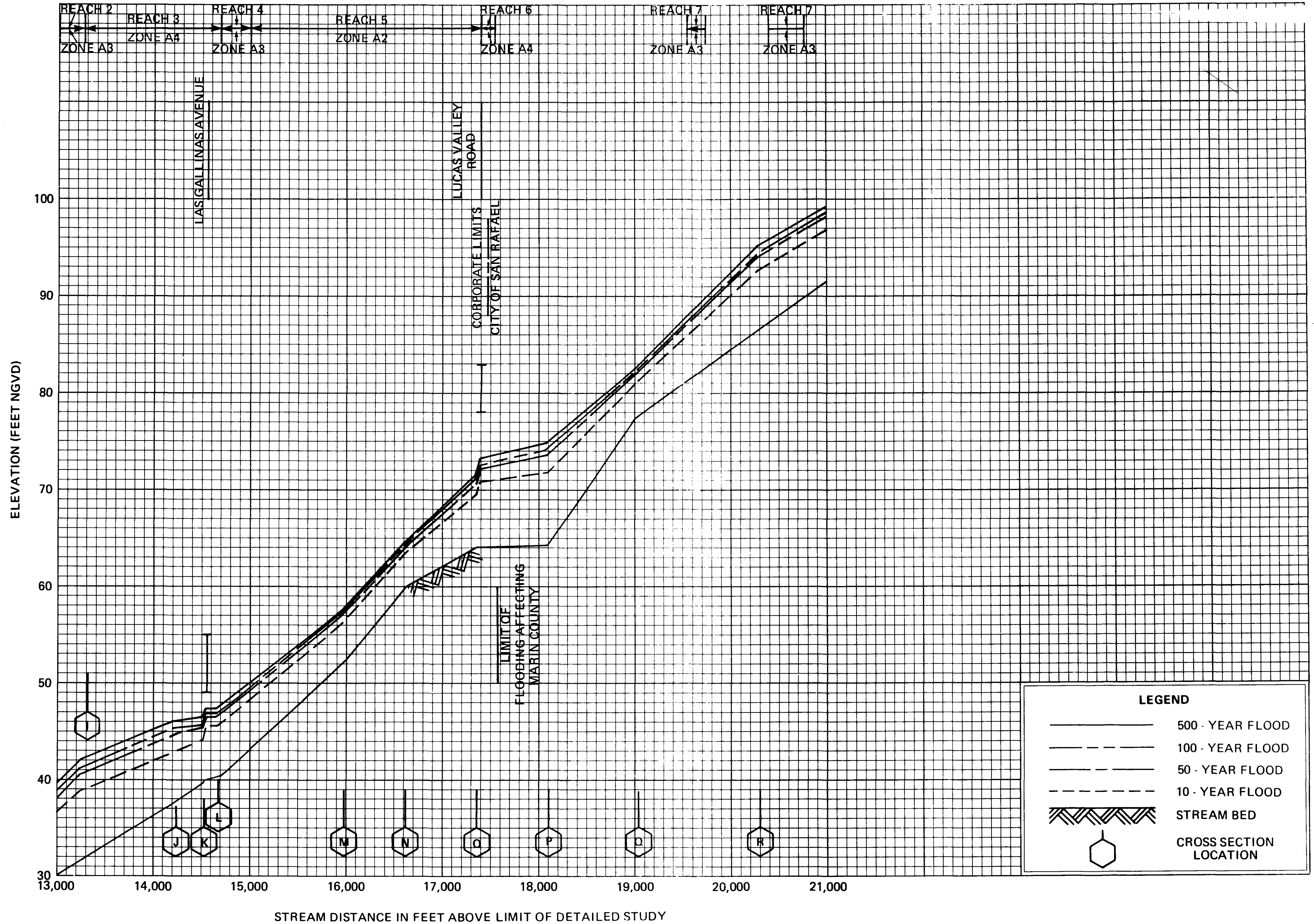
FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

FLOOD PROFILES

MILLER CREEK

17P



FLOOD PROFILES

MILLER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

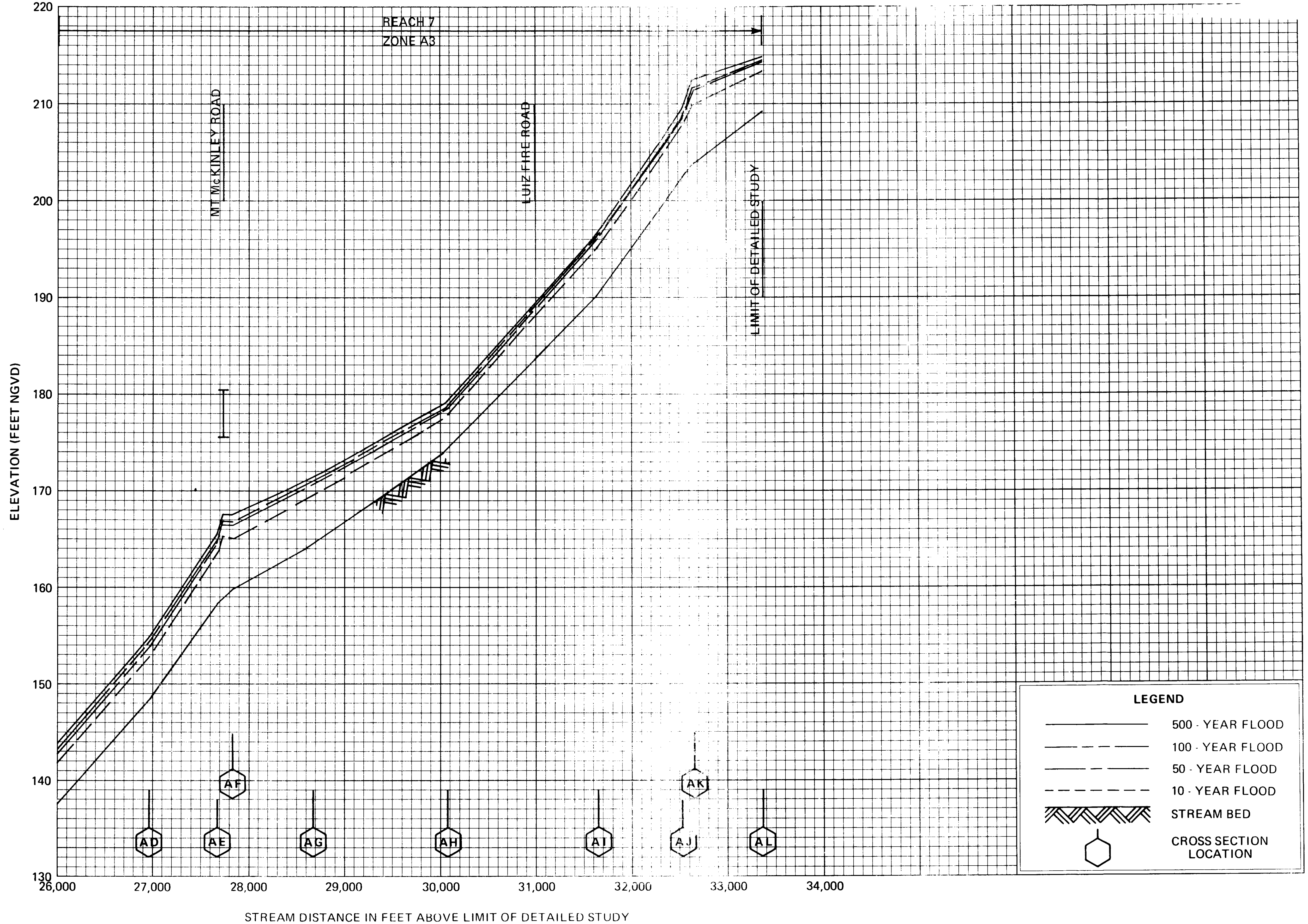
18P

FLOOD PROFILES

MILLER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)



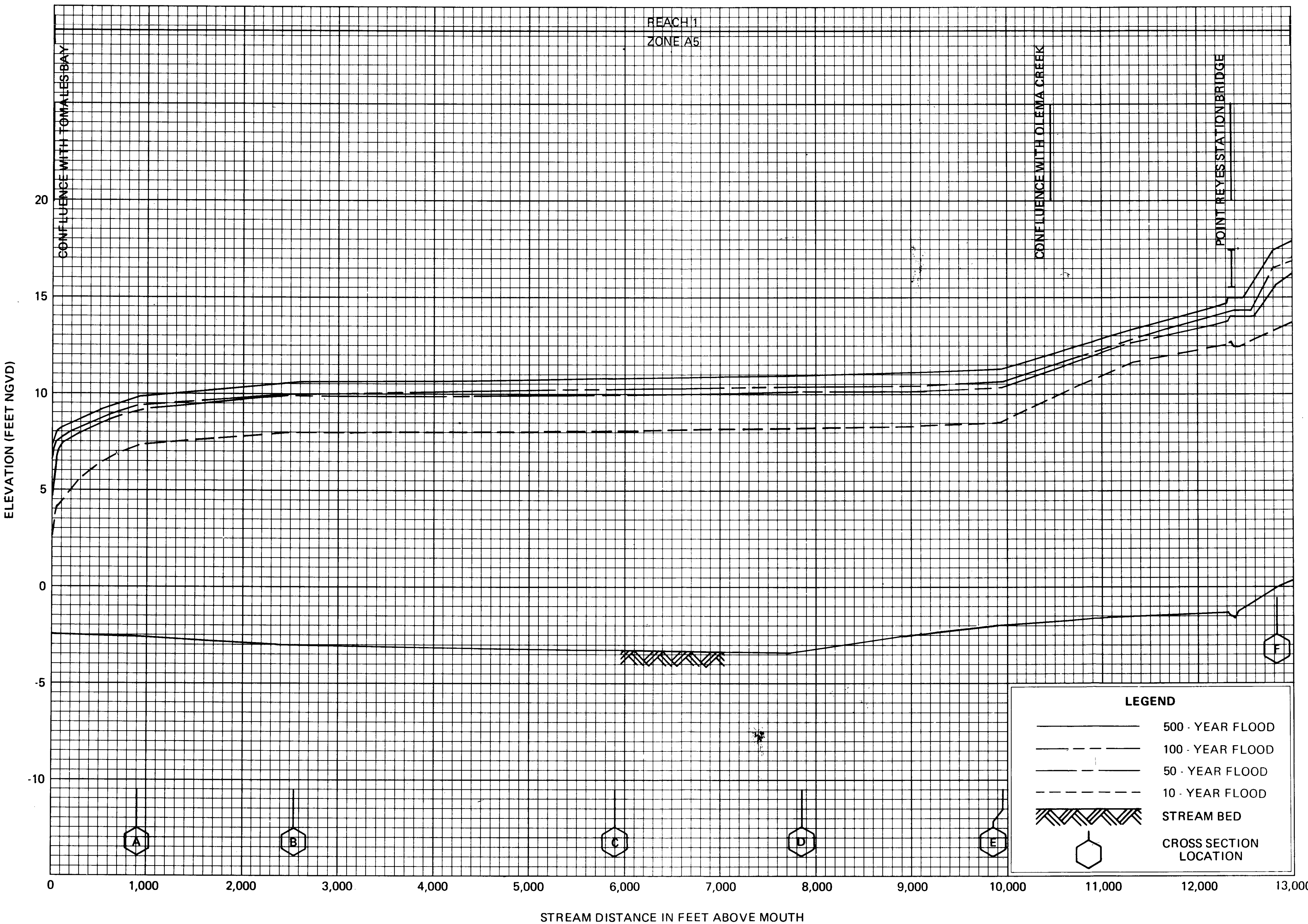
FLOOD PROFILES

MILLER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

20P

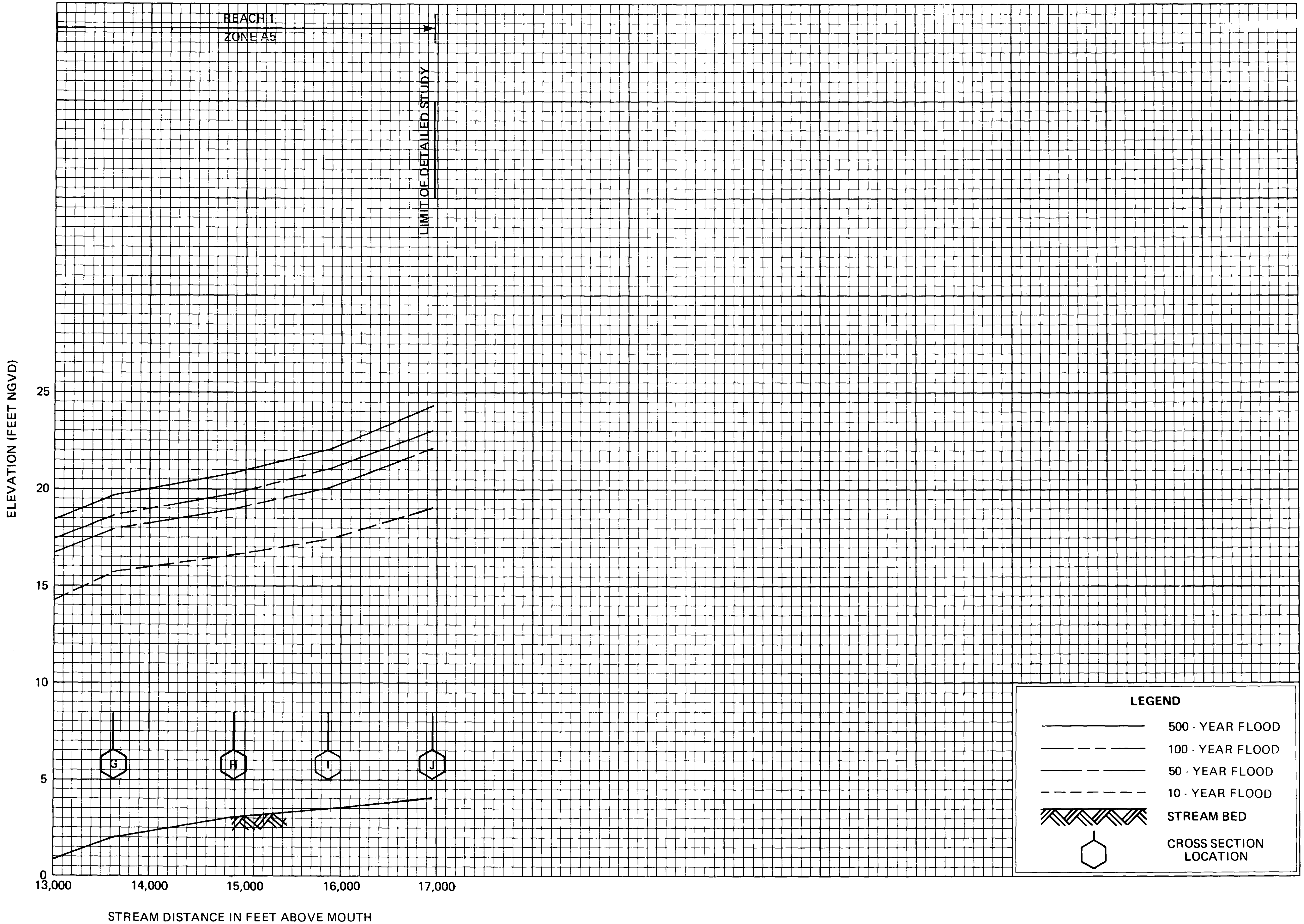


FLOOD PROFILES

LAGUNITAS CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

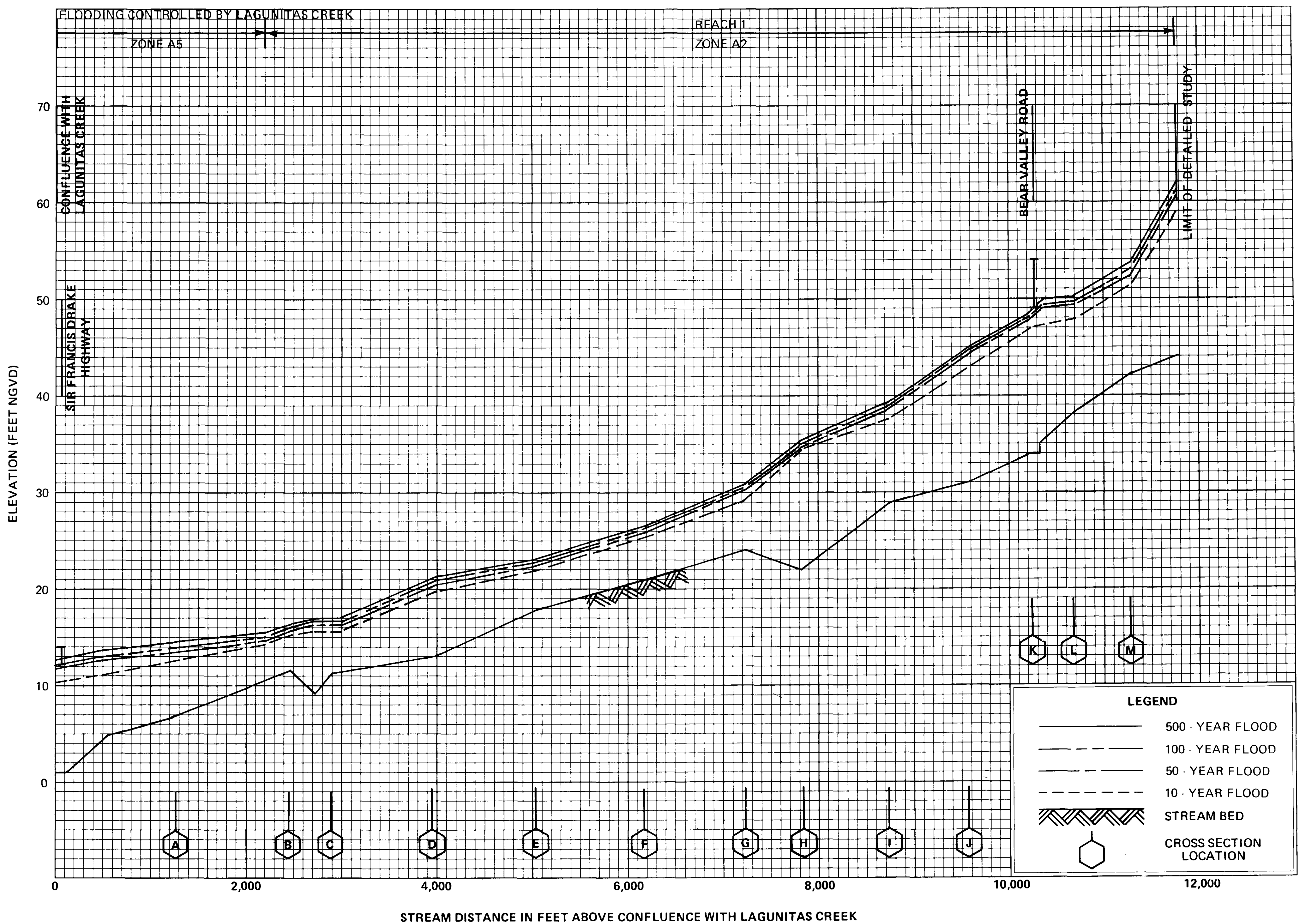


FLOOD PROFILES

LAGUNITAS CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)

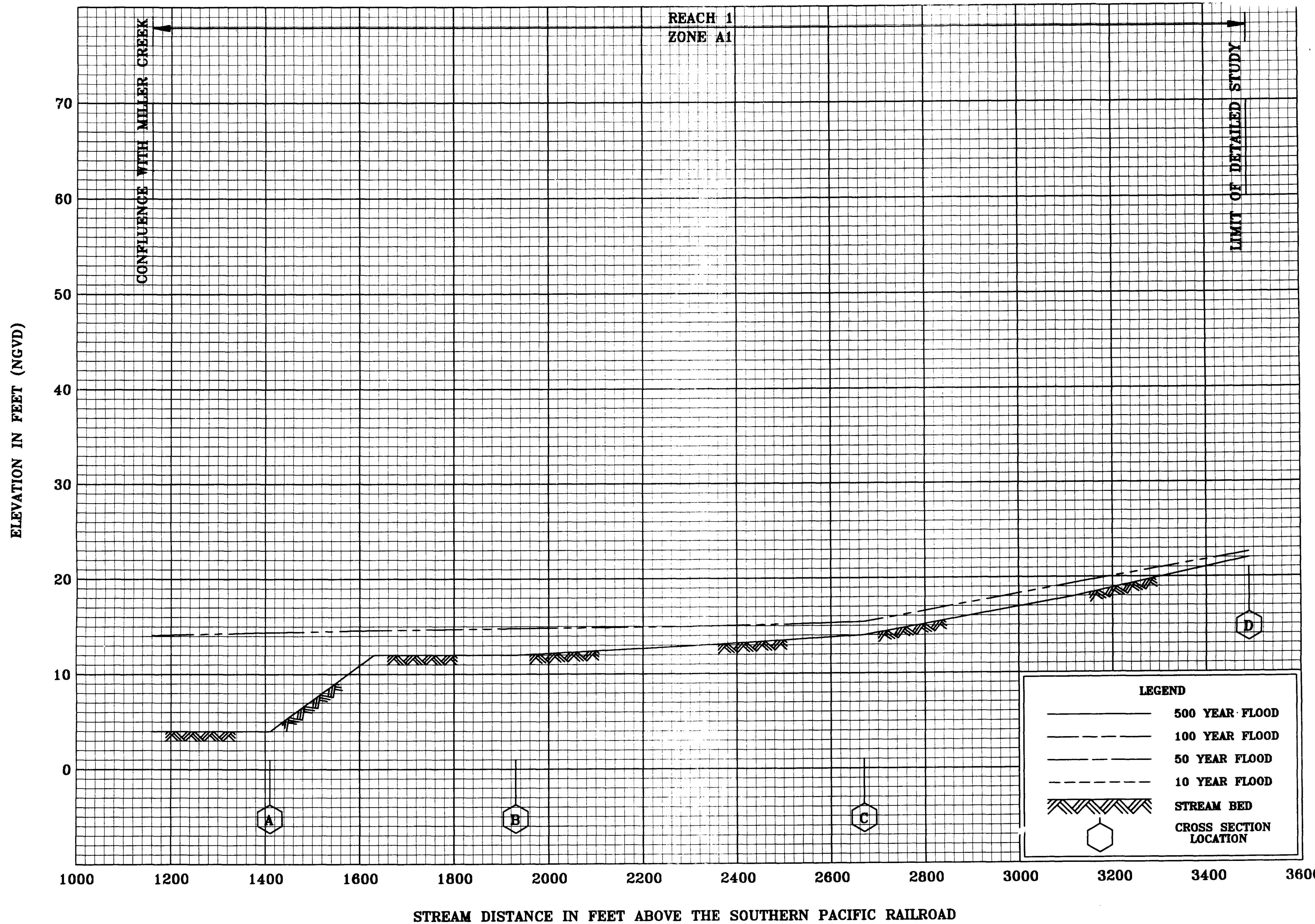


FLOOD PROFILES

OLEMA CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA
(UNINCORPORATED AREAS)



FLOOD PROFILES

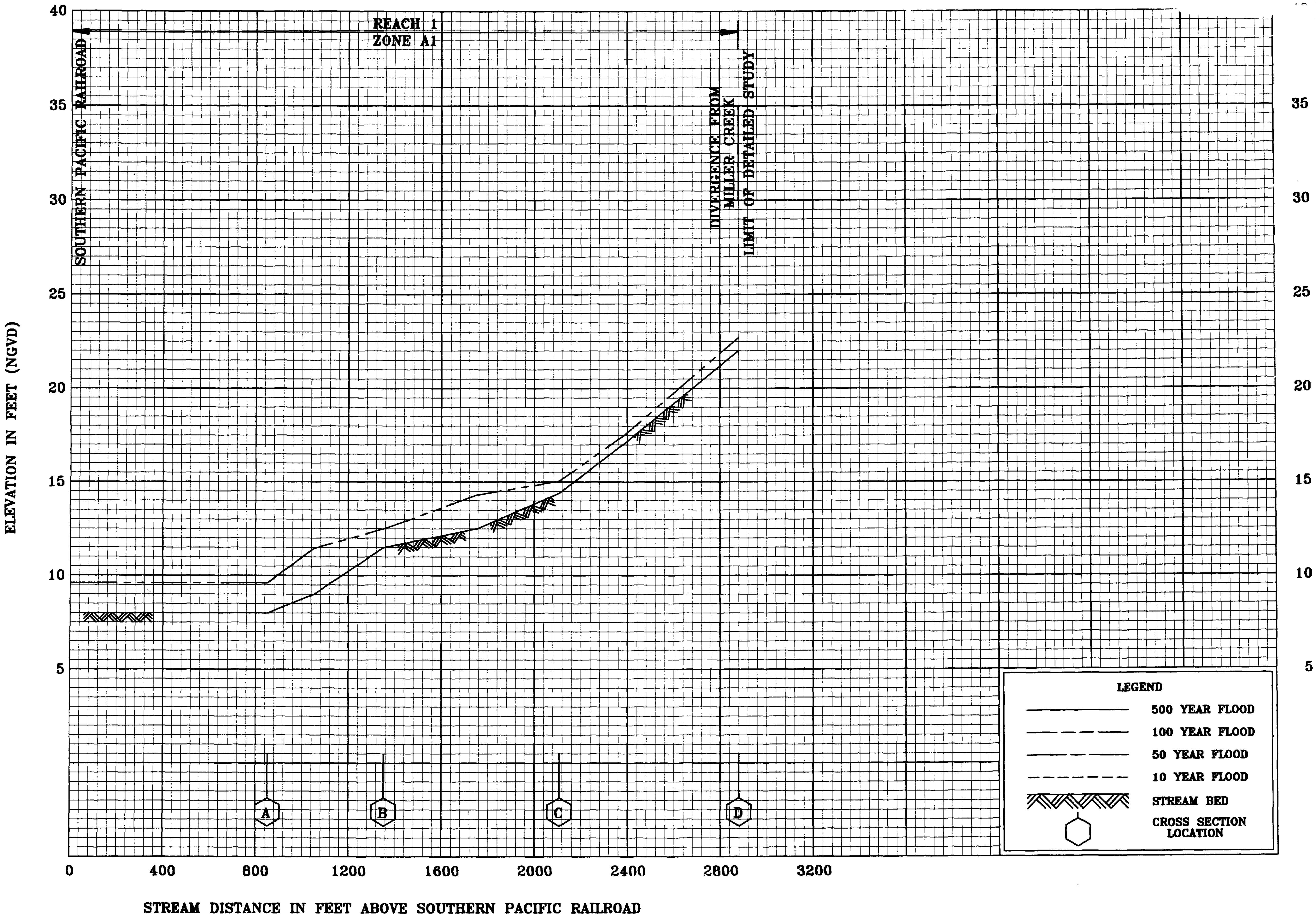
MILLER CREEK - LEFT OVERBANK CHANNEL

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA

(UNINCORPORATED AREAS)

24P



FLOOD PROFILES

MILLER CREEK - RIGHT OVERBANK CHANNEL

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARIN COUNTY, CA

(UNINCORPORATED AREAS)

25P